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Contents

FRONTISPIECE	SIR GORDON RADLEY
PAGE 1	THE CHALLENGE OF 1957
2	SIR GORDON RADLEY'S INAUGURAL ADDRESS
5	A RESISTIVITY SURVEY IN THE WASH AREA *by* G. F. TAGG, B.SC.(ENG.), PH.D., F.INST.P., MEMBER
8	THE GRAHAM CLARK LECTURE
9	THE SECTION CHAIRMEN'S ADDRESSES
12	THE TECHNOLOGY OF CALDER HALL
16	A REVIEW OF THE *PROCEEDINGS*, PARTS A AND B
30	OBITUARY
31	WIRING REGULATIONS—RECENT INTERPRETATIONS
33	CORRESPONDENCE
36	MONOGRAPHS AND PAPERS PUBLISHED INDIVIDUALLY THIS MONTH
38	FORTHCOMING EVENTS AT SAVOY PLACE
39	BRITISH NUCLEAR ENERGY CONFERENCE: FORTHCOMING PROGRAMME
40	SOME RECENT BOOKS
41	LIBRARY ACCESSIONS
43	NEWS FROM ABROAD
46	LONDON REPORT
49	NEWS FROM THE CENTRES
51	CONTENTS OF THE CURRENT ISSUES OF THE *PROCEEDINGS*
52	ANNOUNCEMENTS TO MEMBERS
54	DISTRICT MEETINGS
55	OFFICERS OF THE INSTITUTION
56	COMMITTEES, 1956–57
59	LOCAL CENTRE COMMITTEES, 1956–57
63	OVERSEA REPRESENTATIVES OF THE COUNCIL
63	OVERSEA BRANCHES, COMMITTEES, AND JOINT GROUPS
65	REPRESENTATIVES OF THE INSTITUTION ON OTHER BODIES
71	CODES OF PRACTICE COUNCIL
72	LOCAL HONORARY TREASURERS OF THE BENEVOLENT FUND
xxv	Index of Advertisers

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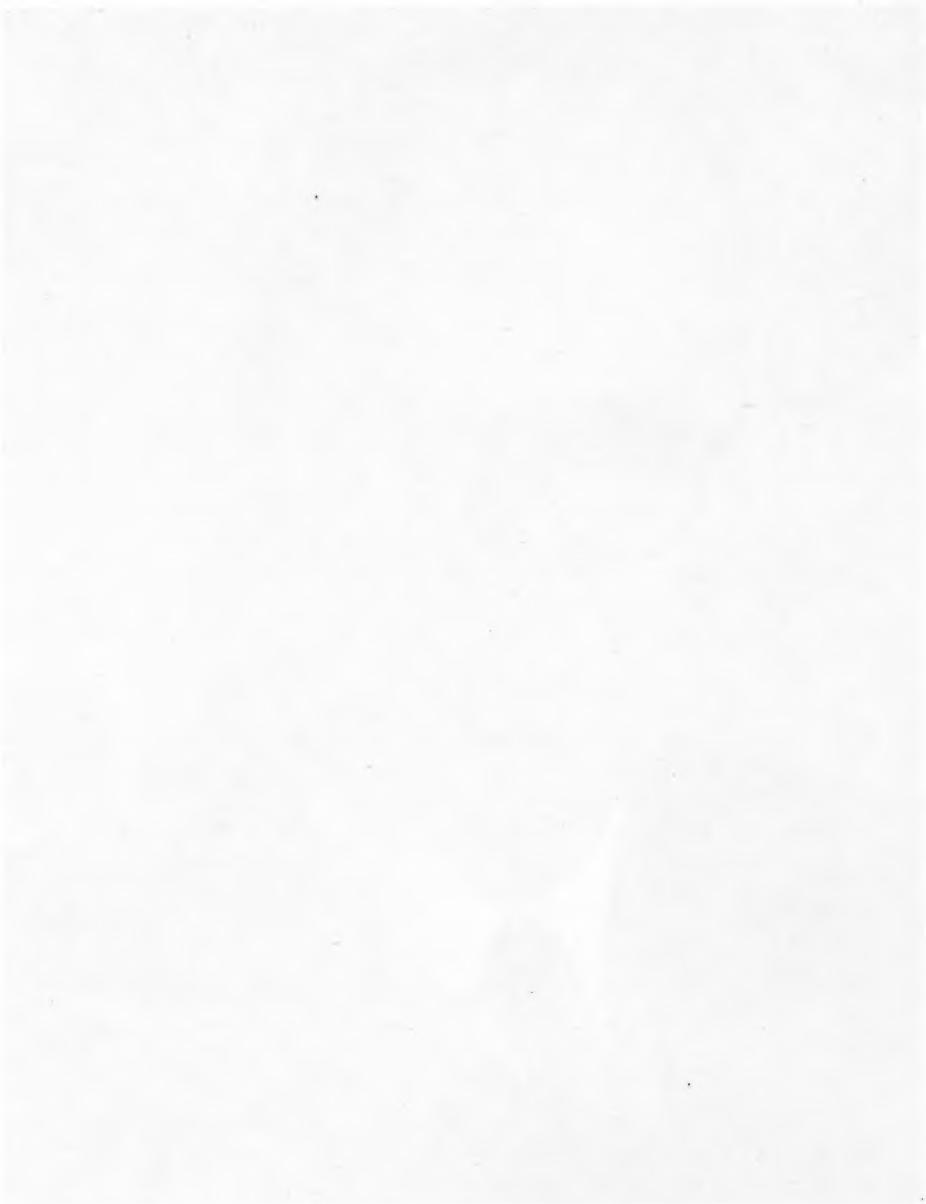

SIR GORDON RADLEY PRESIDENT 1956–1957

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THE CHALLENGE OF 1957

IT IS A TRADITIONAL PRIVILEGE OF THE PRESIDENT TO be allowed the first page of the January *Journal* for a New Year message to his fellow-members. In many ways the year that has just ended has not fulfilled our expectations. For a few critical weeks towards the close of 1956 the dread possibility of a third world war seemed suddenly nearer. Our vital interests in the Middle East have been in jeopardy. We are finding it harder to sell our goods abroad, the necessary measures that have been taken to preserve the national economy are proving irksome and labour is stirring restlessly. There is no ready solution to our problems. But the like of these things has happened repeatedly in our history. This time they appear against a slightly different setting.

The year 1956 saw two achievements which will long be remembered in the annals of electrical engineering.

When the Queen opened Calder Hall in October, nuclear fission was definitely added to the short list of usable sources of energy for supplying the insatiable demand for electric power. The event came as a welcome counter to the fear of the atomic weapon that has been taking shape since the dropping of the first bomb on Hiroshima. It gives cause for satisfaction on two other counts: because the world's first full-sized atomic power station has been designed by British scientists and built by British engineers, and because it offers a way out of a dilemma caused by the coal that is not being mined and the oil that has to be imported.

The opening of the transatlantic telephone cable for public service in September added another link uniting English-speaking peoples. Completion of this, the first transoceanic telephone cable, turned long-cherished dreams into a reality. It was done only through engineers on both sides of the Atlantic contributing all they had of experience and know-how. There was international co-operation without reserve.

Calder Hall and the cable. The one gives a promise of the power that spells a higher standard of living; the other is a symbol of what may yet be done by sovereign States working together for a common purpose. But neither came easily. Each was the work of a great team of scientists, engineers and technologists who dared to try before they could see all the way to a goal that they would not believe was unattainable.

The answer then lies in people—in people working together co-operatively and creatively. It is the task of The Institution to provide the conditions in which electrical engineers can do this.

By themselves, neither the power stations we build, nor the communications we provide, nor all our other modern scientific and engineering developments can bring that peace on earth and good will among men, of which we have once again been reminded in the Christmas message, and I make no apology for the appeal that I enclose for Hungarian students. I need hardly remind you of our responsibility to ensure, as far as we can, that our achievements as professional engineers contribute to that goal which is gained primarily by 'steadfastness in righteous convictions, and by reasonable common sense and prudence'.

I send to all my fellow-members my sincere good wishes for 1957.

W. T. Ralley.

SIR GORDON RADLEY'S INAUGURAL ADDRESS

'Communication—At Home and Oversea'

The following is a summary of the address delivered by Sir Gordon Radley, K.C.B., C.B.E., Ph.D.(Eng.), on his inauguration as President of The Institution on the 4th October 1956. The complete text and illustrations will appear in both Part A (February 1957) and Part B (January 1957) of the Proceedings.

At the opening of his address Sir Gordon traced the development of The Institution from its start as the Society of Telegraph Engineers to the present day. Originally its members were mostly concerned with the practice of telegraphy throughout the country: to-day they were engaged in a great variety of occupations, extending from the generation of electric power from nuclear sources to the application of electronic control in industrial processes. The uses of electricity had, in fact, become essential to every phase of contemporary existence; social, business and national defence. The Institution had adapted itself to this growth, first by change of name and enlargement of its scope, secondly by formation of the Specialized Sections to cater particularly for such fields as radio, supply, etc. Sir Gordon warned his audience that, despite these useful arrangements to deal with specialized interests, there could be no hard and fast boundaries between the so-called 'light-current' and 'heavy-current' technologies, especially at a time of rapid advance such as the present.

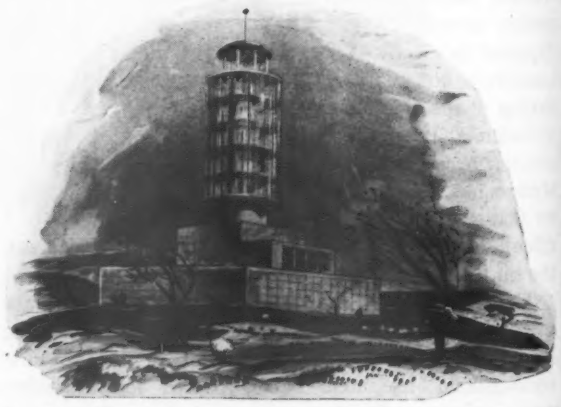
Touching on the place of the engineer in society, he reminded his audience that, partly as a consequence of the Second World War, the scientist had won his way into the inner councils of the nation. But in public administration, and in industry, there was just as great a need for the engineer as for the scientist. The Institution, appreciating the importance of the professional electrical engineer in our national life, had always had careful regard to the standards of professional qualification. Rapidly changing technology had in no way diminished the need for practical training and experience.

Sir Gordon turned to his main theme—world telecommunication. He dealt first with inland communication, and recalled that during the past twenty-five years the results of scientific research had been most apparent in increasing the facilities for long-distance communication. Cables transmitting 600 speech channels within a single coaxial tube had been installed between the main centres of population. The same line plant, with appropriate repeaters to transmit a somewhat wider band of frequencies, is used to provide television links rented to the broadcasting authorities. As traffic demands and opportunity offers, it is proposed to reduce the spacing between repeater stations on some British routes to about three miles, and so enable existing cables to cater for about 1 000 telephone channels plus a 405-line television channel on each tube. This kind of development imposes difficult technical requirements on the design of the repeaters, and in any case its realization depends on the availability of valves with a performance superior to that of any at present in use in this country.

Sir Gordon compared the modern radio relay system with the hill-top beacons of the first Elizabethan era. A radio relay system, operating on carrier frequencies above 1 000 Mc/s, has stations at intervals of twenty to fifty miles, each station having a line of sight to its neighbours. The facilities were now much greater than with fire beacons—and so were the difficulties. In order to build a radio station on a hill in rural England it is necessary to obtain the consents of at least twenty-five authorities. Fig. 1 shows an artist's impression of what relay stations of the future may look like.

The introduction of nation-wide dialling by telephone subscribers poses two problems—the first is numbering, the second is charging.

From the subscriber's point of view, the most convenient solution to the first is a national numbering scheme which will enable the wanted subscriber to be obtained by dialling a code independent of the place of origin of the call. Thus, if the wanted subscriber is in Glasgow the caller should have to dial the same code, whether he is in Aberdeen or Brighton. The equipment must do the thinking to determine the routing of the call from Aberdeen or Brighton—or anywhere else—to Glasgow, which may be complicated. This complex routing equipment will not be used for local calls, but in devising the numbering system the Post Office has



1 *An artist's impression of a new design for a hill-top radio relay station*

assumed that it must allow for 20 million subscribers connected to 8000 exchanges.

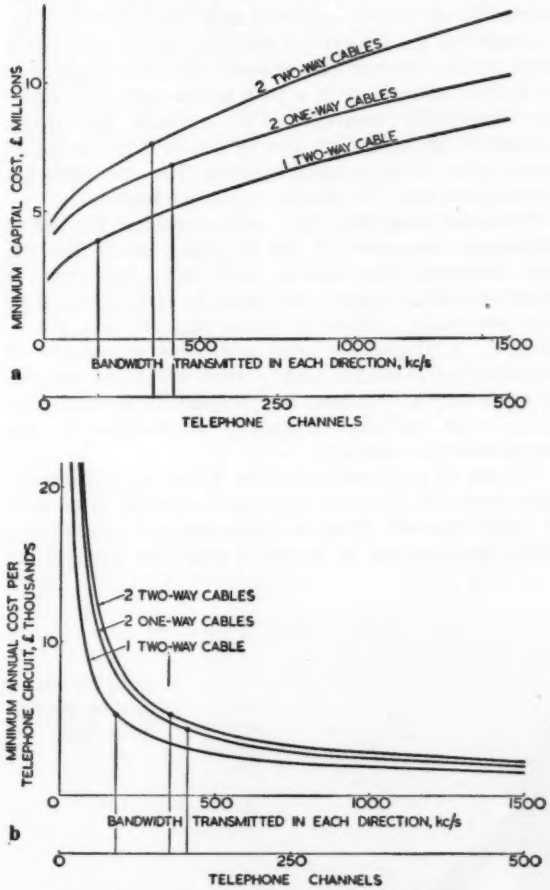
Charging for trunk calls is now based on a ticket made out by the operator in respect of each call. Continuation of this practice when all operations are fully mechanized is clearly impossible. There are two alternatives. The first is the use of automatic message-accounting equipment of the kind that has been developed and is being used in America. The second is the metering of all calls with bulk billing.

Electronic techniques are likely to revolutionize the art of telephone switching within the foreseeable future. In America, the Bell Telephone Laboratories hope to have a fully electronic exchange in public service by 1958. Development of electronic exchanges is at an interesting stage. The philosophy of the switching has been worked out in terms of broad functional designs. The speed with which our ideas can be realized in the form of a cheap and compact exchange depends on the production of apparatus for performing the various functions. Sometimes there are alternative methods for doing what is required; for example, cathode-ray tubes with thousands of tiny capacitors deposited on the screen, assemblies of cheap mass-produced ferrite cores, and delay lines, are three different forms of electronic memory for storing large amounts of information. Their future relative popularity will depend on how improvements take place.

Dealing next with international communication developments, Sir Gordon reminded his audience that the concept of a transatlantic telephone cable, having submerged repeaters at intervals to increase its traffic capacity, was first described to The Institution by Dr. Buckley in the 1942 Kelvin Lecture. Sir Stanley Angwin, in his Presidential Address the following autumn, had taken up the theme of transatlantic communication. A general description of the design objectives for the new transatlantic telephone cable system was given in a paper read before The Institution in November 1954. The system itself was completed last August. Only the advent of the submerged repeater had made the long submarine telephone cable possible, because the attenuation of the high-frequency signals required to transmit even one telephone channel is very rapid as the signals pass along the cable. In the new multi-channel transatlantic cable the loss at the highest frequency transmitted, 164 kc/s, is about 1·6 dB per nautical mile. At this rate of attenuation the input of a 100 MW generating set could not be detected by the most sensitive galvanometer more than 150 miles away. The loss is made up by the insertion every 38 miles of a repeater with a gain of 65 dB—equivalent to a power gain of over a million times. The combination of cable and repeaters gives a system free from loss, but one which depends on the continuous operation of much electronic equipment at the bottom of the ocean.

Completion of the transatlantic project, Sir Gordon said, marked the opening of a new era in the growth of world communication, and one which was revolutionary in its possibilities because of the very large traffic capacity of repeatered cables. This new development was of great interest to British engineers for many reasons. First, the United Kingdom had a unique tradition in the manufacture of submarine cable, and a manufacturing capacity which had been greatly increased and modernized in the last few years. Next, British research on thermionic valves and British circuit techniques were likely to exert a major influence on submerged-repeater practice during the next decade, and, lastly, more than half the world's total mileage of submarine telegraph cable was British owned. In examination of repeatered submarine telephone cable systems, Sir Gordon dealt both with double-cable systems, using separate cables for the two directions of transmission, and with single-cable systems, providing both-way transmission on the one cable. The latter are cheaper, especially where the traffic requirements are not great, and more flexible; but in both the cost of the system decreases very rapidly as the number of telephone channels is increased (Fig. 2).

The practical limitations to cable systems are (i) the



2 *Costs of cable systems for a distance of 2000 n.m.*

(*a*) Capital costs. (*b*) Annual costs.
The three ordinates indicate limits of capacity set by present construction technique.

maximum voltage which can be applied to energize the repeaters, (ii) the minimum spacing at which it is practicable to insert repeaters, and (iii) the maximum size of coaxial cable it is practicable to lay and recover.

The 51 repeaters of the new transatlantic cable are energized in series by a direct current fed along the centre conductor in common with the high-frequency speech currents. A total driving voltage of 4000 volts is required, the centre conductor being about 2000 volts positive to the sea at one end and 2000 volts negative at the other. Sir Gordon said that repeaters could be adapted for a higher voltage.

While the laying of flexible repeater housings which are adequate for one-way cable (Fig. 3) is simple (it has been carried out in a gale), the laying of large rigid housings (Fig. 4) necessary for both-way repeaters at present requires the manual help of practically all the deck crew of the cable ship.

The operation could not be carried out in bad weather. Laying machines differing entirely from the proved and conventional drum have been suggested, and at least one has been installed in a cable ship, but there is no real experience yet of how successful and reliable they will be.

Regarding the limitations imposed by the size of the cable, Sir Gordon said that research had been undertaken on a form of cable with a high-tensile-steel core which was torsionally balanced. This prevents the major hazard, in laying and recovering conventional cable, of stored turns in the armouring wires. The new cable has other attractions with respect to weight and cost.

Transistor amplifiers have been suggested for use in underwater repeaters. In the present state of the art, they compare unfavourably with valve amplifiers in power-handling capacity and noise level, and would be only marginally suitable in other respects. The art is, however, a progressive one, and when transistors of improved performance and proven reliability become available they will increase the prospects of building long cables with sufficient frequency bandwidth for the transmission of television.

The use of undersea telephone cables on routes other than across the Atlantic must be considered in relation to traffic demand. From a comparison of populations, circuit requirements to Australia and New Zealand are probably not more than 10% of those to North America. With costs as high as they would be, cable clearly cannot compete with radio on cost for the provision of small groups of circuits for very long distances.

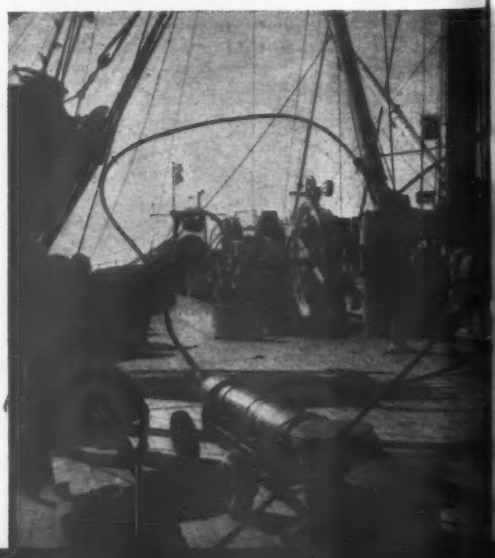
Sir Gordon then reviewed the development of long-distance radio circuits, which have been much improved. More channels have been accommodated in the 3–30 Mc/s band, but the limit to the number of long-distance circuits that can be used in this band makes it certain that it alone cannot satisfy the growing demand for world communication. Neither has it been possible to achieve complete reliability. It seems clear that continuous communication cannot be realized over such difficult routes as the North Atlantic or to the Antipodes.

The challenge to the engineer is to provide cable facilities on the main world trunk routes on a scale which has hitherto been regarded as appropriate only on land. Rigid housings will be required for the repeaters in order to allow duplication of components and both-way working. What is required is a means for laying repeaters of this kind in deep water without all the hazards which attend such operations at present. Development of some form of mechanical gear for doing this as part of a continuous cable-laying operation is the immediate task.

A technical and economic study is being made for a cable from the United Kingdom to Gibraltar, which would appear to be a useful first step in building up communication facilities on routes other than the North Atlantic—to West Africa and to South America via the Azores.

Sir Gordon concluded by saying: 'I have departed from the tradition of the last few years in that I have not mentioned in the course of this address our great need for more engineers and technologists, or the means of training them. I have instead described a few of the things that are waiting to be done by engineers—things in which I, myself, am particularly interested. If an echo of what I have said reaches some who are still on the brink of a career and kindles in them enthusiasm for electrical engineering, or even gives an added impetus to those of us who are already embarked on its practice, I shall be satisfied. The profession represented by this great Institution can do much to serve the Nation, the Commonwealth and the world at large.'

3 (left) *Flexible repeater passing through cable-laying gear*



4 (right) *Rigid repeater being taken past cable-laying gear*

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A Resistivity Survey in the Wash Area

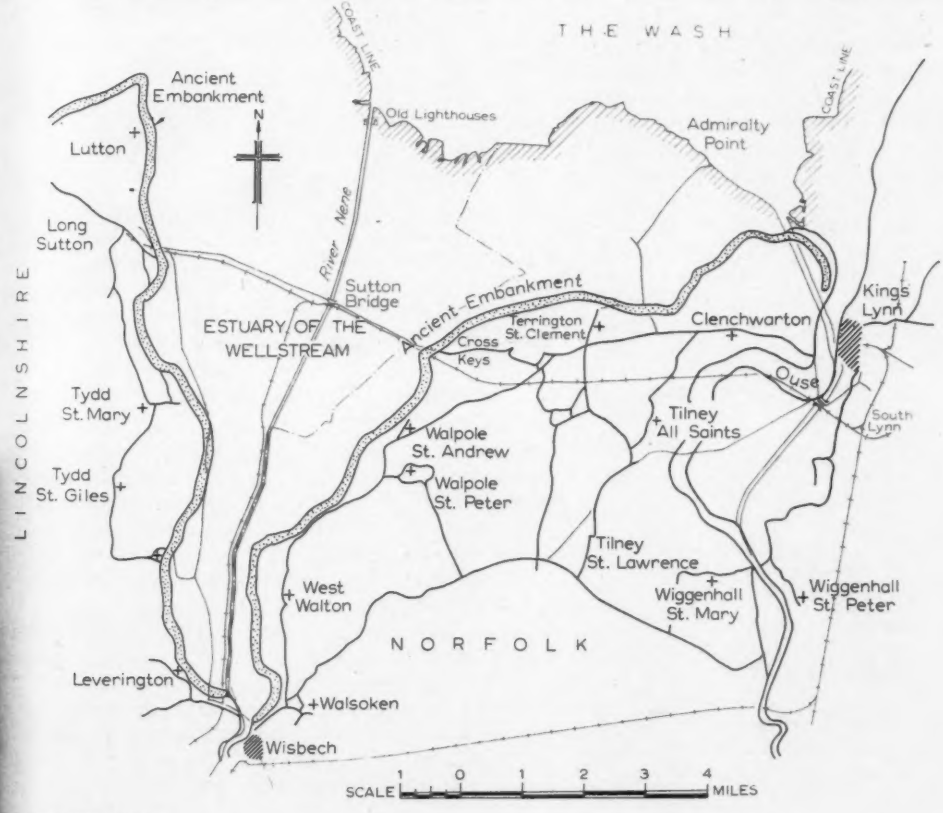
G. F. TAGG, B.SC.(ENG.), PH.D., F.INST.P., MEMBER

Many legends and more authentic traditions exist in these islands about treasures that have reputedly been lost in the past and not yet found. Whether these are believed to be sunk in the sea or buried in the soil, attempts to find them have a fascination that has often spurred people to great efforts. One of the traditional buried hoards whose existence is more certain than many is King John's famous treasure—'lost in the Wash'. An association called the Wash Research Committee has for some years been engaged in organizing a new search for this treasure, and recently the interest of a well-known firm of instrument makers has enabled a start to be made. A resistivity survey of the district was carried out last autumn, to try to find the position of the causeway over which King John may have travelled. The method depends on the variation in apparent soil resistivity caused by the presence of compacted soil among the predominantly sandy ground. Dr. G. F. Tagg, who has been conducting the survey, here outlines the apparatus used and the method employed. The results of the survey have been analysed within the last few weeks. Dr. Tagg stresses that his preliminary survey is a long and problematical march from the uncovering of the treasure, supposedly scattered in the reclaimed ground near the mouth of the River Nene.

Introduction

It is a matter of popular tradition that in October 1216 King John lost his baggage train while attempting to cross the estuary of the Wellstream, from east to west. Now known as the Nene, the Wellstream flows into the Wash on the borders of Lincolnshire and Norfolk. The historical evidence that such a disaster did occur is very strong, and there is also evidence that, prior to this, King John had collected together in his own keeping his personal belongings and valuables which had been deposited in various monasteries for safe keeping. There is possibly some doubt whether the whole of this was lost with the baggage train, but it seems almost certain that some such disaster did occur and that it was one of the factors contributing to the death of the King a few days later.

This matter was the subject of a paper read by W. St. John Hope before the Society of Antiquaries in



1 *A conjectural map of the Wash Area in 1216*

The coast-line and some topographical features as they exist to-day are shown in green.

——— Roads

-|—|—|- Railways

. — . — . County boundary

London in 1906.* He reviewed all the available evidence and came to the conclusion that the disaster did occur, suggesting the line of the crossing. A conjectural map of the area in 1216 is shown in black in Fig. 1 (p. 5), and St. John Hope suggested that the crossing occurred in a straight line from Cross Keys to Long Sutton. It will be appreciated that the whole of this estuary is now reclaimed land; the present sea coast is a few miles to the north and is shown in green in Fig. 1, together with a few present-day landmarks.

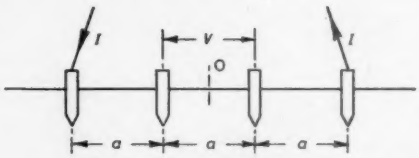
This paper aroused much interest, and a number of people jointly investigated the matter more fully. These people later formed themselves into the Wash Research Committee. After sifting carefully all the available evidence, they decided that St. John Hope was correct in his major conclusion that a disaster did actually occur, but they differed from him about the most probable place. Two World Wars and other events have intervened, and it is only recently that something definite and practical has materialized from their work.

The Way across the Estuary

According to contemporary accounts, the estuary consisted mainly of quicksands uncovered at low tide, with a number of channels carrying the outfall from various rivers, some of these channels being fordable at low tide. Now if it was possible to find a way across from one bank to the other sufficiently firm to support the passage of a horseman or a wheeled vehicle, there must have existed a path through the quicksands consisting of more dense or tightly packed soil. Since the solid ground underlying the quicksands is clay, it is reasonable to suppose that this clay formation came nearer the surface at certain points or that clay became mixed with the sand, making a denser and firmer medium. Such a medium would almost certainly have an electrical resistivity differing from that of the surrounding sand, and so a resistivity survey of the area should give some useful information about the presence of the path.

The Resistivity Method

The resistivity method of surveying has been fully described on a number of occasions, and briefly may be explained as follows. Four electrodes are driven in the



2 *The resistivity method of surveying*

earth in a straight line at equal intervals a, as in Fig. 2. A known current I is passed between the outer electrodes, and the voltage drop V between the inner electrodes is measured. The ratio V/I gives a resistance R.

* Hope, W. St. John: 'The Loss of King John's Baggage Train in the Wellstream in October 1216', *Archaeologia*, Second Series, 1906, 10.

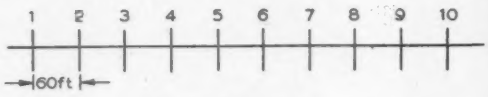
If the earth were perfectly homogeneous, i.e. of a constant resistivity ρ, then

$$\rho = 2\pi aR$$

In practice the soil is not always homogeneous, and the value of ρ calculated from this formula, which is now called an apparent resistivity, will be found to vary with the electrode separation a. It is from these variations that deductions can be made as to variations in the nature of the underlying soil.

The instrument used was a Megger earth tester, which measured the resistance R directly on a moving-coils ohmmeter, and is so designed that it is unaffected by electrolytic e.m.f.'s at the electrodes or any stray currents flowing in the soil.

There are two main ways in which surveys of this type are arranged. If it is required to probe into the ground to various depths, then the centre point O (Fig. 2) of the electrode system is kept fixed, and the electrode separation a is increased. By this means it is possible to investigate variations in the ground immediately beneath the point O. If on the other hand it is desired to detect variations in the depth of a known structure, a suitable electrode separation is chosen and kept constant and the whole electrode system moved bodily to various points in the area. This is the method used in the Wash area, and since the approximate depth to the clay was known to be about 40 ft, an electrode separation of 60 ft was chosen. The general plan was to set out a number of electrodes along a straight line—a 'traverse line'—as



3 *The line traverse*

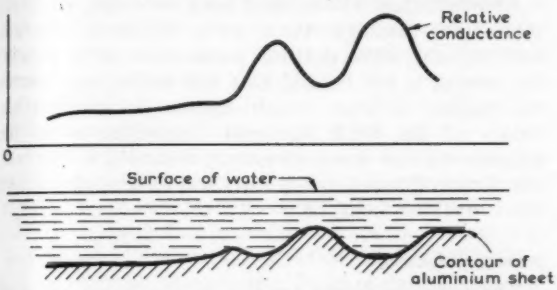
in Fig. 3, and to make tests using first electrodes 1, 2, 3, 4, then 3, 4, 5, 6, then 5, 6, 7, 8, etc. Since the electrode separation was 60 ft, this means that measurements were made at points 120 ft apart. Successive traverse lines were also as far as possible kept 120 ft apart.

Tests on a Model

It was felt from the outset that it would be unwise to carry out a long series of tests in the field without some knowledge of the variations in resistivity which might be expected if the theory of the nature and position of the path was correct. A model was accordingly constructed, so that the results which might be expected under ideal conditions could be determined. The model consisted of a bath in which water was placed to represent the sand. An early depth test in the actual area under consideration had yielded the information that the lower medium of clay had a lower resistivity than the sand above it, and this was accordingly simulated in the model by a sheet of aluminium beaten up into a shape to represent the proposed path. Four electrodes were used, as in Fig. 2, and arrangements were made so that measure-

ments could be made along a series of parallel traverse lines.

The results obtained from this model have been very helpful. In Fig. 4 the lower curve is the contour of the aluminium sheet along one of the traverse lines, and the upper curve gives the measured conductance at various points along this line. The conductance, or reciprocal of the measured resistance, was chosen, since it was expected that as the lower-resistance material came nearer to the surface, the resistance would drop, i.e. the conductance would rise. Thus the conductance curve would have the same general shape as the contour of the metal. One interesting and useful point which emerged from these tests is that when the traverse line passes over a rise in the surface of the aluminium plate, the conductance curve shows a double hump. As the electrode system approaches the rise, the conductance increases, but as the electrodes pass over the rise, the conductance falls—

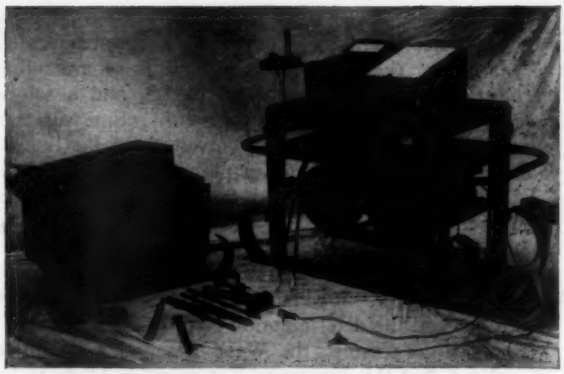


4 *A typical result on the model that was constructed to investigate variation in soil resistivity with variation in height of subsoil*

to rise again as the electrodes leave the rise and finally to fall as they become well clear. This effect was observed to a greater or less extent in all tests, and is being used in an analysis of the field results. The drop in conductance as the electrodes travel over the rise is probably due to a constriction in the current path at this point. These model tests were sufficiently encouraging to make it appear possible to detect the presence of the more conducting path if it existed, although it was appreciated that they were made under ideal conditions, particularly as regards the surface; in the field it would be necessary to take into account the effect of surface variations such as roads, dykes, etc.

The Field Equipment

This survey consisted of a large number of traverse lines, and it was realized from the start that the equipment used must be designed for ease of handling and speed of operation. In addition to the instrument, it was necessary to supply steel electrodes and connecting cables, and it must be appreciated that the greater part of the time was used in setting out electrodes and connecting up, while only a comparative small part was used in taking the actual readings. Again, the equipment had to be used on



5 *The equipment used in the survey*

ploughed fields, fields of stubble, grass fields and in orchards, and this had a very definite influence in its design.

The equipment was finally constructed as shown in Fig. 5. On the right is the main trolley mounted on steel skis. These were chosen in preference to wheels, since it was felt that with skis the trolley could be pulled over any of the types of ground to be encountered, whereas considerable difficulty would be experienced with wheels. The actual field experience fully confirmed this later. On the left on top of the trolley will be seen the instrument and to the right of this a sloping writing desk holding the results sheets. The trolley itself was built of aluminium angle, the skis being of steel. A shelf was provided immediately under the top for auxiliary equipment, waterproofs, etc. Under this were the four cable drums, two in the front and two at the back. These drums, each holding 300 ft of cable, were mounted on axles, but with friction springs to prevent overrunning. Links were also provided which, when closed and locked, served the double purpose of locking the drum in place and of connecting the inner end of the cable to the instrument terminals through a busbar system. The cables on leaving the drums passed through slots in the aluminium angle, these slots being fitted with spring leaves so that some tension was always kept on the cable either while pulling out or reeling in. A later provision, not shown in the photograph, was vertical rollers on each corner of the trolley to guide the cables when these are drawn off from the trolley at an angle. The trolley was fitted with tow ropes and carrying handles for lifting into and out of a van, over ditches, etc. The total weight was such that it could be lifted easily by two men. The two hoops leaning against the trolley drop into slots in the angle and serve to carry a waterproof cover when this is required.

On the left of Fig. 5 will be seen the tool box, also mounted on skis. This contained the electrodes, hammers, measuring tapes and small tools. Some of these can be seen in the foreground. The electrodes were ½-inch diameter steel rods about 15 inches long.

Use of the Equipment in the Field

The manner in which the equipment was used depended very largely on the nature of the ground. In general a line of electrodes was laid out as in Fig. 3, and a set of measurements made as described in connection with this diagram, the equipment being moved along the line to successive testing points. On a ploughed field or in an orchard it was towed by hand, but on grassland or in a stubble field it was towed by a van. In Fig. 6 a reading is being taken in a ploughed field, and in the background can be seen one of the marker posts used for lines of electrodes. Fig. 7 shows the initial setting out of the electrodes and the determination of positions.

For various reasons, the Wash Research Committee considered that the causeway, if it exists, is likely to lie to the south of the position suggested by St. John Hope.

6 *Taking a reading in a ploughed field*

7 *Setting out a traverse in a field of stubble*

In practice the resistivity survey was carried out over an area of about two square miles lying between Tydd St. Giles and Walpole St. Peter.

Results

Approximately 130 traverse lines were run, requiring over 1000 readings. These have now been carefully analysed, and while it is not possible as yet to publish the results, it can be said that this preliminary survey has yielded evidence which appears to confirm the theory of the Wash Research Committee as to the location of a way across the estuary of the old Wellstream. Much more detailed survey work will be necessary before this is finally established.

Acknowledgment

The author's thanks are due to the Wash Research Committee, and to Evershed and Vignoles Ltd. for permission to publish this information, and for making it possible to carry out the survey.

THE GRAHAM CLARK LECTURE

The Graham Clark Lecture will be given this session by Sir Ifor Evans, D.LIT., on the 7th February 1957, in the Institution building at 5.30 p.m. His subject will be 'The Place of Engineering in University Education'. The meeting will be held jointly with The Institutions of Civil and of Mechanical Engineers.

Sir Ifor has been Provost of University College, London, since 1951. After being Professor of English at a number of universities and at one time Educational Director of the British Council, he became Principal of Queen Mary College in 1944. During his period of office the college decided to develop its Engineering Faculty, and the first stage of this development has been concluded by the completion of a nuclear engineering laboratory.

Whilst Provost of University College, London, he has been associated with the college's appeal for funds to erect a new building for the Faculty of Engineering. As a result £350000 has been raised from industry for this purpose, while the University Grants Committee has added £120000.

Sir Ifor is the author of a number of books, including 'The Use of English' and 'Science and Literature'.

Among other outside activities, he is Chairman of *The Observer* Trust, and of the National Insurance Advisory Committee. He is the holder of the Legion of Honour and of the Order of the Crown of Belgium, and is an Honorary Doctor of the University of Paris.

THE SECTION CHAIRMEN'S ADDRESSES

Short summaries of the addresses of the Chairmen of the Specialized Sections for the current session are given below. Either the full text, or a long abstract, of each address is being published in the January (Part B) or February (Part A) issue of the Proceedings.

MEASUREMENT AND CONTROL SECTION

The Measurement of Radioactivity

The address was delivered by the Chairman, **Denis Taylor, M.Sc., Ph.D.,** *on the 9th October 1956.*

THE STUDY OF RADIOACTIVITY AND ITS MEASUREMENT WAS at one time the province of the physicist. With the industrial development of atomic energy in recent years it is now equally the province of the electrical engineer. A radioactive substance, as is well known, disintegrates with the emission of nuclear particles (α-particles or β-particles) and/or photons (usually γ-rays), and the measurement of the rate of particle (or photon) emission provides a convenient method for the assay of such material. This is discussed from the point of view of the ultimate sensitivity of radioactive assay, and it is shown that this sensitivity can be very great. It is pointed out that in practice the ultimate sensitivity is determined very largely by the background counting rate of the detector (i.e. the counting rate in the absence of the substance to be assayed), and a review is made of methods of reducing this background counting rate. Some examples are given, and it is stated that, for β- and γ-counting, detectors of about the normal size can now be made with background counting rates of about one count per minute. This is by the use of detectors of special design, and the use of an anti-coincidence ring of further detectors to cancel the effect of cosmic rays. On the other hand, detectors for α-particles can be made with a background counting rate of about one count per hour, and further reduction of this rate is possible using a pulse-amplitude analyser to select events in the desired energy range.

A number of problems are discussed in connection with the measurement of radioactivity. These include

(i) The measurement of the radioactivity of the human body.
(ii) Radioactivity measurements relating to nuclear reactors.

In connection with the former problem it is pointed out that this involves measurements down to 1×10^{-8} curie or less, and some examples are given of the measuring techniques which have been used successfully. Two basic methods are employed. In the first system an array of high-pressure ionization chambers is used in association with an electrometer valve or vibrating-reed electrometer circuit. This is suitable for measurements of the gross activity, which in unexposed persons is due mostly to the naturally occurring radioactive isotope ^{40}K. The second system uses an array of scintillation counters in association with a pulse-amplitude analyser. This second method allows the identification of the nuclides present as well as an activity determination. Some examples of the use of such apparatus in atomic energy work are given.

The second problem discussed is the measurement of fission rate in a nuclear reactor. It is pointed out that this is usually determined indirectly on the basis that the neutron flux pattern throughout the reactor core remains constant; a measurement of the neutron flux in or near the core then gives an indication of the fission rate. Some of the consequences of the use of this method are discussed, and the design of the neutron-flux detectors and of the associated calibration apparatus for the determination of flux distributions throughout the reactor core are described.

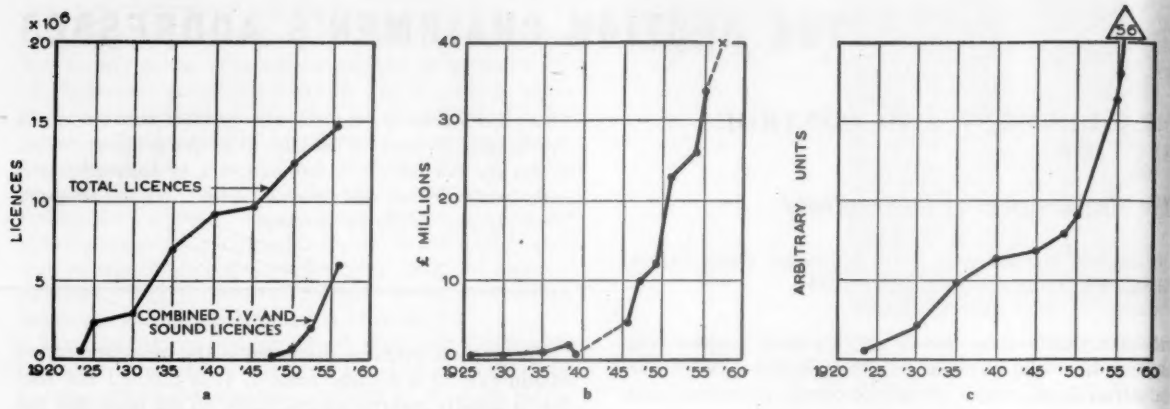
RADIO AND TELECOMMUNICATION SECTION

The Electronic Age

The address was delivered by the Chairman, **R. C. G. Williams, Ph.D., B.Sc.(Eng.),** *on the 17th October 1956.*

SINCE THE STONE AGE THE DOMINANT MATERIALS AND techniques of successive periods have marked the progress of civilization. The twentieth century, in which we have begun to understand and make use of the subatomic particles, should logically be called the 'Subatomic Age', and our profession has identified itself with the electron, which is the most easily freed and the most mobile of the subatomic particles. Basic effects such as the conduction of metals, the capacitance effects in insulators, the piezo-electric phenomena in certain crystals, photo-electric and photoconductive devices, phosphors, and the newer transistors and ferrites, are all concerned with the behaviour of electrons in the solid state, and most of the large research and development laboratories of the world to-day are working intensively in this field.

The radio and electronic industry has grown rapidly during its short history, largely resulting from the public demand for entertainment and instruction by radio and television. It is now comparable in size with our most important industries and employs some 200000 persons with an annual turnover of over 200 million pounds in equipment and components, of which 34 million pounds represent exports; this is an export figure which is only just below the corresponding one for the United States.



1 *Growth of domestic licences, exports and production capacity*

a Radio and television licences. **b** Exports. **c** Production capacity.
× Estimated at rate for the first seven months of 1956.

As an industry it is representative of the broad field of exports due to technical brain-power, on which the future of this country depends, following the decline of our staple industries and the loss of our investment income. Further growth is dependent on the encouragement of an adequate intake of qualified engineers and technologists to hold our own against our main competitors, the United States and Russia. We are still producing too low a proportion of engineering and science graduates, and not only must this proportion be increased but we would be well advised to welcome more women into our profession.

New materials and techniques are important in our professional and industrial development, and the following are worthy of special mention:

1 Semi-conductors, from which have been developed transistors and associated devices; in these the vacuum of a valve is replaced by an artificially produced crystal lattice.

2 More efficient phosphors with wider ranges of stimulation and emission for television development, medical diagnostic apparatus, and electroluminescence as a new and more efficient light source.

3 Ferrites, for high-frequency circuits, magnets, memories, and microwave switching. This new class of material, together with transistors, constitutes the most important post-war component development in the electrical engineering profession.

4 Miniaturization and printed circuits for smaller units and mechanized production techniques.

These new materials and techniques have important applications throughout the electronic field. Smaller, lighter and cheaper radio and television receivers are possible, with new lines of attack on the many problems of colour, and new apparatus for research, production, test and control through industrial television. In communication, electronic telephone exchanges and the development of submarine telephone cables may before long enable us to dial direct from our own home telephone over a large part of the world. Applications to automation are making vital improvements in our production efficiency with all its effect on the export trade. In atomic energy, little progress could be made without electronic control, while in new weapons, reductions in size, weight and power consumption are essential.

Technique is advancing so rapidly with the developments of subatomic physics that our production of power and its control, and our means of communication and measurement, offer a world of industrial exploration comparable to the geographical opportunities of the past. With wise planning and sound engineering, we, in this country, can make of our opportunities as much as did our forefathers a century ago.

SUPPLY SECTION

Engineering Efficiency, Economics and Expediency

The address was delivered by the Chairman, **P. J. Ryle, B.Sc.(Eng.),** *on the 24th October 1956.*

THE THREE NOUNS IN THE TITLE REPRESENT ASPECTS considered, consciously or otherwise, in any engineering project; attempts are made to explore both the degrees to which they can be separated and the extent to which they overlap or conflict. Efficiency and economics are assigned meanings more or less corresponding to normal engineering usage; expediency covers a huge field of considerations at first sight extraneous to, but nevertheless often of great practical bearing on, choice and design.

The efficiency of power generation is, in general, not susceptible to very noteworthy improvement, except at disproportionately high capital cost; economics are therefore decisive. Power-station siting is much influenced by expediency. For steam stations, the engineering or primary considerations are largely concerned with access, cooling-water facilities, sizes and shapes of site areas required, and foundation conditions; such, broadly speaking, refer to what the engineer wants. So-called

secondary considerations, in general comprising what other people do not want, nowadays often rival the primary ones in importance.

A water-power station must, of course, be sited where nature provides adequate potential energy. The flooding of upstream areas may involve abandoning habitations and diverting roads, railways, etc. Aesthetic objections are frequent, although, on completion, people often agree that the scenery is improved. Fish and fishermen must, of course, suffer minimum disturbance!

Transmission often involves triangular battles between efficiency, economics and expediency. Overhead-line design levels are really nothing more than expedient compromises, expedient in that they give standards of service traditionally accepted as fair enough. The true optimum design would be such that the sum of the annual cost, the annual cost of losses, and the annual cost of outages would be a minimum; unfortunately, any generally applicable assessment of outage costs is inconceivable.

The straightest line route is, of course, the most efficient, but in mountainous country, especially where winter conditions are severe, expediency often demands a longer route, close to roads, for operational access.

Two single-circuit lines are more reliable than one double-circuit line, but the latter is cheaper, only requires one route to negotiate, and halves the number of towers to litter the landscape. In a projected scheme involving several circuits ultimately, but only two initially, financial expediency may be decisive in line design; simple difficulties of raising money may force the adoption of a scheme involving minimum initial capital outlay, even at the expense of efficiency and the economics of the ultimate development.

The design of overhead-line river crossings often introduces strife between the three considerations. There is nothing standard about a river crossing; minimum clearance to water may necessitate tall towers, but the Air Ministry may limit overall height. Such conflicts and local topographical restrictions may lead to the need for special conductors and difficult tower siting problems.

Analysis of the picture in which efficiency, economics and expediency represent the three primary colours proves as inconclusive as would be spectroscopic examination of a Turner or a Titian. The picture reproduction is worthless, but the frame may have certain virtues.

UTILIZATION SECTION

Balanced Development and Diversity of Applications

The address was delivered by the Chairman, **H. J. Gibson, B.Sc.,** *on the 11th October 1956.*

AN APPROXIMATE ANALYSIS OF THE HOUR-BY-HOUR demands on an electricity system supplying a mixed load shows that the contributions made to the load curve on a typical winter day by the three main groups of consumers are complementary to each other. An examination of daily load curves and of a composite demand curve for three winter months confirms a substantial diversity of usage between the three groups, but reveals the periods during the day and night when additional load could be added to improve the load factor of the system.

The present position has been brought about by the continually extending use of electricity and its adaptation to an increasing variety of applications in factories, homes and commercial premises. The conclusion is drawn that, if this is to be improved, the three groups must be developed in unison and constant attention given to selective development.

The necessity of making the maximum use of distribution plant, particularly in the rural areas, is emphasized, and attention is drawn to possibilities of encouraging summer loads.

The particular benefit to overall economies invites ingenuity to provide means of using electricity during the night. Because of custom and habit this presupposes methods to store the energy given up by electricity during the night for use during the day.

A variety of relatively new and lesser-known applications of electricity are briefly described in the address to illustrate the direction of some of the activities of the Commercial Engineers of Area Boards to satisfy these requirements. The importance to electricity users of load factor and power factor is also brought out in the illustrations, some of which show the desirability of close co-operation of supplier and consumer.

For example, the cycle of operation of large arc furnaces of 30 000 kW capacity for the production of lower-grade steels requires a high demand during the melting period and a much lower demand during the soaking period. If the working cycles of two or more furnaces are staggered, which can be done without affecting production, the maximum demand can be kept for certain periods of the day during the winter at a reduced figure specified by the supply authority. This arrangement makes it possible for them to quote a special tariff the demand component of which has a commensurately low value.

The recently introduced twin intermittent electric pottery kilns, which are capable of firing decorating gloss and biscuit at temperatures between 650° C and 1 200° C, supersedes the traditional coal-fired bottle kilns and has running costs some 45% lower. This serves to illustrate the conversion to an electrical method of a process previously done in another way. The alternate operation of the twin kilns results in a load factor of about 90%, thus improving the overall economy of operation.

The wide diversity of use within each of the three main groups of consumers is of equal importance to the diversity between groups. Many applications having individually low load factors can play as important a part in the general improvement as those of higher load factor, and a number of examples of this kind are given.

The delivery of the address was accompanied by a film which illustrated the applications that are used as examples.

The Technology of Calder Hall 621.311.25

One result of the building of the world's first full-size nuclear power station is the amassing of a quantity of new knowledge, which, after ten years' hard work by hundreds of experts in diverse fields and three years of actual construction of a novel plant to unprecedented standards of accuracy, is truly prodigious. To disseminate this knowledge to the public and to place it on permanent record as a mark of an historic occasion, a timely symposium was held by the British Nuclear Energy Conference, at the Central Hall, Westminster, on the 22nd–23rd November 1956. The papers and discussions will be published in the April and July issues (1957) of the Journal of the British Nuclear Energy Conference.

The supply engineer's province

A pleasant feature of the turbine hall at Calder Hall is the skilful use of colour. The four alternators and condensers are painted in pastel shades of pink, blue, yellow and green.

AFTER the exploit comes the story—and few stories have ever been more eagerly awaited. The response to the announcement of the Symposium on Calder Works Nuclear Power Plant was so great that even the capacious building of The Institution of Civil Engineers would have been inadequate for the number of applicants, and the B.N.E.C. Board therefore decided to hold the meetings at nearby Central Hall.

The symposium consisted of nineteen papers by leading men in the Atomic Energy Authority and large industrial organizations. In order to allow the maximum time for discussion, the papers were not read individually; instead related papers were introduced in groups by one speaker for each group.

Fittingly, Sir John Cockcroft, Director of the Atomic Energy Research Establishment at Harwell, was the chairman on the first day. The opening lecture was delivered in a vigorous style by Sir Christopher Hinton, Managing Director of the U.K.A.E.A. Industrial Group, who spoke on the place of the Calder Hall type of reactor in nuclear power generation. With such a welter of speculation about other types of reactor, such as the liquid-cooled, the heavy-water-moderated, the enriched and the fast-neutron types, Sir Christopher's lecture was invaluable in assessing the true worth of the gas-cooled graphite-moderated natural-uranium reactor. The Calder Hall type of pile

'. . . has the distinction of forming the basis of the world's first comprehensive long-term programme for the development of nuclear power and it is essential that we should be quite clear why it occupies a position of such distinction.

'The art of the engineer is, and always has been, to make use of available scientific knowledge, materials and techniques to produce plants which are sufficiently economical and reliable to be used in industry. He must be quite firm in setting on one side scientific theories, however attractive, if he has not got at his disposal the materials and techniques which enable him safely and reliably to translate these theories into industrial practice. . . . The Calder Hall piles are heavy, cumbersome and expensive in capital cost per kilowatt, but they are inherently safe, they use natural uranium as a fuel and their construction makes use of materials which have been in routine production for a considerable time and of techniques which are either well established in themselves or are normal developments of established techniques.

'The figures given in the White Paper show that reactors of the Calder Hall type can produce power at a cost comparable with that of a modern station using conventional fuel.

'In engineering plant which has to be sold to industrial operators these are solid and vital advantages, and at to-day's date the Calder Hall type of reactor is the only nuclear power plant for which these claims can be made.'

Thus, while Sir Christopher recognized that eventually the Calder Hall reactors will be superseded by other types with higher rating, in his view it is likely that they will still be built twenty-five years from now.

In the course of his lecture Sir Christopher gave some interesting forecasts of the future of nuclear power, by analogy with other types of prime mover in the history of engineering. He showed how both the weight and the cost per horse-power of steam and oil engines had decreased rapidly and steadily with the passage of time, as better materials and designs became available. Assuming a similar rate of decrease for nuclear reactors, he forecast that by the end of the century the weight per horse-power should be reduced by a factor of ten—from

2000 to 200 lb/h.p.—while the capital cost should be reduced to half of its present value of £125/kW.* The importance of this is clear from the fact that the capital costs for a nuclear power station represent two-thirds of the total price of electrical energy generated, while for a conventional plant they represent only one-quarter.

Another interesting fact mentioned in Sir Christopher's address was that, owing to the urgent need for additional plutonium for defence purposes, the design of Calder Hall was optimized for plutonium production, and that electrical power is therefore a by-product. It follows that '. . . from the industrial point of view it would be misleading to talk about the cost of electrical power produced in the reactors at Calder Hall; the industrial cost of power from reactors of this type can be determined only from designs for reactors which are optimized for the production of electrical power and which produce plutonium as a by-product.' The minor differences in design required by optimization for power production affect the efficiency of the reactor and hence the cost of electricity.

Sir Christopher Hinton's address was followed by the introduction by Mr. R. V. Moore of two papers which described the design study of Pippa (the code word for 'pressurized pile producing power and plutonium') carried out at Harwell from 1951 to 1953, and the design and construction of Calder Hall from 1953 to 1956. Fig. 1 shows the station in the course of construction. The total weight of the biological shield and the reactor is about 20000 tons on an area about 60 ft square, giving a pressure of 6 tons/ft². Since the allowable ground pressure is only 2·5 tons/ft² the whole structure was 'floated' on an 11 ft-thick concrete raft, 130 ft long and 104 ft wide. Mr. Moore, who is Assistant Director (Civil Reactors) of the U.K.A.E.A. Industrial Group, and who was personally responsible for much of the work, gave a general picture of the operations of design and construction, not only of the reactor but of all the ancillary plant as well.

After Mr. Moore's introduction to the papers, Sir George Nelson opened the discussion by congratulating the members of the Atomic Energy Authority on their fine work. Mr. Harry West, referring to the recent tenders for the building of nuclear power stations, said that industry has had to undergo an examination and has written its answers on many tons of paper. Needless to say, they were awaiting the results anxiously. Striking a more serious note, he mentioned that there was a considerable market for the export of small nuclear power stations to countries which had no atomic energy industry of their own. Experience showed that the average size of power stations required abroad was 30 MW.

Mr. A. L. G. Lindley suggested that improvements were needed in the steam cycle and that future stations should aim at the largest possible reactor—this is, the largest pressure vessel.

Sir Claude Gibb struck a rousing note by declaring his belief that historians will recognize the Calder Hall symposium as the most important conference for human welfare that has ever been held, either scientifically or politically, and he stressed that in due course nuclear power will liberate us from our dependence on imported oil from the Middle East.

Mr. F. H. S. Brown was perturbed by the possibility that during shut-down periods the water in the small-bore pipes of the heat exchanger might freeze, with consequent damage, and he asked what had been done to protect them. Mr. G. F. Kennedy raised the point that the life of 20 years attributed to the nuclear plant compared unfavourably with plant of conventional design, and wanted to know whether at the end of this period Calder Hall would have to be shut down completely. Another speaker asked what was meant by 'inherently safe', and what the likelihood was of a brittle fracture of the pressure vessel.

1 *Design for concrete*
Steelwork for supporting the biological-shield shuttering is erected.

Replying to some of the questions, Sir Christopher Hinton said that an inherently safe reactor was one which could not become violently uncontrollable if all the mechanical devices failed. In the original Hanford type of heavy-water-moderated pile, for example, the coolant had a greater effect as a neutron absorber than as a moderator, so that if the coolant flow ceased it would no longer be absorbing neutrons and reactivity would be increased. At Calder Hall, too, in designing the control rods the principle had been adopted that the law of gravity always operates. Furthermore, the pile is

* This value is deduced from the White Paper on the earlier power stations of the Calder Hall type, now about to be constructed for the C.E.A.

designed so that as the temperature rises the reactivity decreases, and if the coolant flow ceases the pile cannot get out of control. Failure of the pressure vessel is a possibility and this would spread a certain amount of radioactivity. This risk, however, is probably less than that, e.g., of storing chlorine. Mr. Moore replied to other questions. On the possible freezing of the heat exchangers, he said that 10 days was the maximum shut-down period needed for the *complete* recharge of the reactor. In practice the recharging is never complete and so the actual period would be much less. During this time the reactor still generates heat slightly so that freezing would not occur. The life of a nuclear plant is probably limited by obsolescence more acutely than that of a fossil-fuelled plant.

At the second and third sessions of the symposium, papers were discussed which dealt with various design aspects, metallurgical problems, uranium fuel handling and the heat exchangers.

2 *Pipe dream*
Sampling tubes for the detection of faulty fuel elements.

The fourth session, held on Friday afternoon, was of direct interest to electrical engineers. Four papers were introduced by Dr. Denis Taylor, dealing with the control and instrumentation of the reactor and the detection of faulty fuel elements.

Typical of the numerous problems faced by control engineers was the decomposition of hydrocarbon oils under irradiation, and the paper on control equipment by S. A. Ghalib and J. H. Bowen described the research necessary to find suitable lubricants. The choice and behaviour of materials to be used for the equipment also presented problems, because the properties of matter to which the engineer has become accustomed are often quite different under the unique conditions pertaining to the reactor. For example, only very low concentrations of oxygen and water vapour are permitted in the carbon-dioxide coolant, and the coefficient of friction of most materials (including graphite) increases significantly at these values. Again, quite apart from important considerations of strength, ductility, melting point and neutron-absorption cross-section, the use of any metal liable to form a low-melting point eutectic with magnesium had to be avoided.

The detection of faulty fuel elements, or burst slugs as they are colloquially called, is an important requirement. Normally the uranium is enclosed in a gas-tight can to prevent oxidation by the coolant gas and to prevent the escape of fission products into the coolant stream. It is essential to detect and locate a burst can as soon as the fault occurs, and a paper by E. Long, J. M. Laithwaite and K. W. Cunningham records how this difficult task is performed in the Calder Hall reactors. Samples of coolant are drawn off from the various holes, and any ionized particles are precipitated on a wire by an electrostatic field. The radioactivity of the wire is then ascertained by means of a scintillation counter. To draw off samples of gas from the 1 696 fuel channels in the graphite core involves the use of 40 miles of steel tubing per reactor. Some idea of the complexity of the system is given in Fig. 2.

The two other papers introduced by Dr. Denis Taylor during this session—by R. J. Cox and K. R. Sandiford, and by E. Anderson and J. H. Bowen—were devoted to descriptions of the measurements made to supply the required information to the operators, of the actual procedures used in operating the pile, and of the safety devices and precautions taken.

Opening the discussion on the four papers, Mr. R. S. Medlock said that there was no neat, cute way of detecting burst fuel cans; it was a job that had to be done in a safe, sure and thorough way. He was curious to know, however, whether faulty-element detection was necessary, and whether it would be possible one day to dispense with it. He wondered also why the oxygen content of the feed-water was much lower than was necessary.

Mr. G. T. Shepherd thought that instead of having separate control rooms for the reactor operators and the electrical superintendents, both sets of controls could more logically be placed in one room. This would save manpower and increase safety and efficiency—and decrease the boredom of the electrical engineer. He also pointed out that the water in the boiler of the heat exchanger was sufficient for 12 min on full load, and so the feed-water supply was important. He felt that there was a case for emergency feed pumps.

Mr. K. L. Stretch said that engineers should be ruthless in rejecting anything that proved to be below standard.

He thought that it would be handy to separate the control mechanisms from the charge and discharge cycle, but this was a difficult problem. He made the point that the ideal is to use the reactor as a constant-temperature-difference device—the variation being in the gas flow.

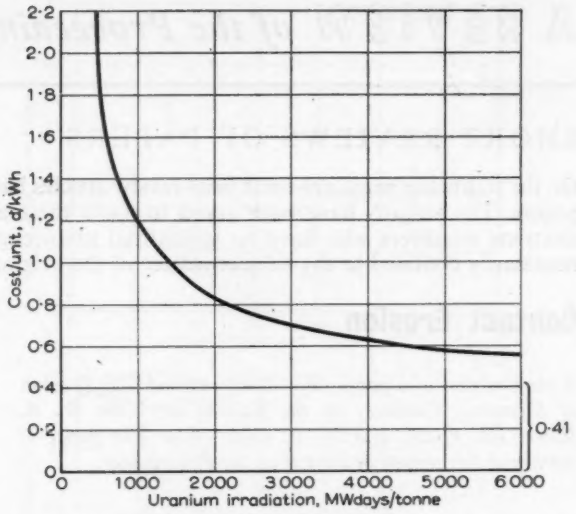
Mr. E. H. Woodhall was concerned about the possibility of deformation of the graphite core, and the possible trapping of the control rods. This could lead to an explosion.

In reply to Mr. Medlock, Mr. Sandiford said that the reason why so much trouble was taken over the oxygen dissolved in the feed-water was that the heat exchangers were complex and it was not easy to do maintenance work on them. The number of installed instruments in the reactor was very moderate. He said, 'If everyone who had wanted to had been allowed to hang an instrument on the reactor we should really have something.'

Mr. Anderson replied to Mr. Shepherd's questions, saying that in an orthodox power station a central control room was practically essential, but Calder Hall had the luxury of separate control rooms. This is because the reactor and steam sides are considered separately. Furthermore, to have combined the control rooms would have required miles of extra wire from the turbine hall. To Mr. Stretch, the Works Manager, he offered the following comment: 'Relations with Mr. Stretch are always excellent provided we tell him how to operate the plant and he tells us how to design it!'

In the last session, again under the chairmanship of Sir John Cockcroft, Mr. R. V. Moore reviewed the future development of gas-cooled reactors, and his paper studied the economics of nuclear power production. He said that if the Calder plant was run entirely as a power station, and no value was attributed to the residual plutonium, it would produce electricity at about a penny per kilowatt-hour. This would not be competitive with coal-fired stations. He then showed how a reduction in cost might be achieved. One important factor, to which the operating cost of generation is proportional, is the efficiency, while the striking way in which the cost falls with the maximum irradiation time of a given charge of fuel is illustrated in Fig. 3. Mr. Moore said that the Calder plant is limited primarily by two design factors—by the thickness of steel plate used in the reactor pressure vessel, which determines coolant pressure and reactor size, and by the maximum temperature of the system, which is limited by a phase change in the uranium at 660° C and by the physical properties of the canning material.

Looking further ahead, Mr. Moore mentioned the possibility of higher-temperature systems (800° C at the outlet) in which metals are excluded from the core, the fuel being ceramic (such as uranium oxide or uranium carbide) and dispersed in the graphite moderator. Many severe problems are associated with this design, but successful development would lead to still cheaper power and to compact systems for which gas-turbine cycles would be economically feasible as an alternative to steam. The overall efficiency of such plant could exceed 40%.



3 *Dependence of cost on irradiation time*

The cost/unit comprises the capital charge of 0·31d./kWh, the operating and maintenance costs of 0·05d./kWh, and the fuel inventory charge of 0·05d./kWh—a fixed total of 0·41d./kWh—plus the cost of uranium replacement.

Concurrently with the symposium, a film of the construction of Calder Hall was shown in the Lecture Theatre of The Institution of Civil Engineers, while an exhibition of models and a short film were displayed in the Great Hall of that building. On the day after the end of the symposium many members travelled to Cumberland to inspect the Calder Hall plant at first hand.

THE SPIRIT OF READING—PREMIUM BLEND

The material part of a premium awarded to a member usually takes the form of books. The member makes his selection; The Institution attends to the buying, embossing and inscription of the books, and then sends them to the member.

Recently a typical collection of such books has been awaiting inscription. A glance at the array of titles confirms the catholic range of interests enjoyed by electrical engineers in general. Among the titles there are, of course, some of those which any member would be proud to be seen perusing: 'Elastic Energy Theory', 'Biometrika Tables for Statisticians (Volume 1)' and 'Relaxation Methods in Theoretical Physics'.

But quite a third of the books strikingly reveal the professional electrical engineer out of school: 'The Oxford Companion to English Literature', 'A Short History of Italian Painting', 'The Age of Inigo Jones', 'The Pocket Guide to Wild Flowers' and 'The Christmas Oratorio of J. S. Bach' (vocal score) are five representative examples.

Johnson said that a man ought to read just as inclination leads him, and it is, perhaps, pleasant to know that some of those who score successes in the Lecture Theatre or in the pages of the *Proceedings* are led for part of their spare time along paths of fascination that lie far from the highways of electrical engineering.

SHORT REVIEWS OF PAPERS

On the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

Contact Erosion

A short review of a paper (No. 2248) entitled 'The Erosion of Electrical Contacts by the Normal Arc', by W. B. Ittner, III, Ph.D., and H. B. Ulsh, M.A. The paper is published this month in Part B of the Proceedings.

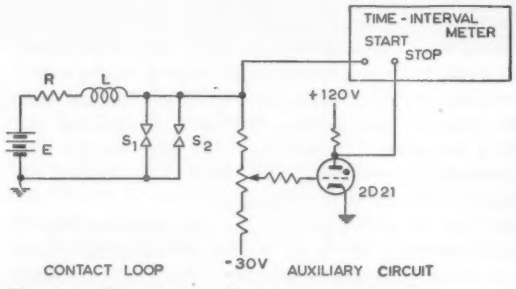
THE SELECTION OF A CONTACT MATERIAL FOR A SPECIFIC switching problem generally involves a considerable number of factors. One consideration of particular interest in the design of modern business machines is the life expectancy of contacts which are required to repeatedly break currents to inductive load devices. Such contacts are subjected to a break arc and, therefore, to a certain amount of arc transfer, which may in time cause a change in the contact timing and eventually complete contact failure. In modern machines a given contact may be required to operate several hundred times each minute, and material transfer at the contacts can occur quite rapidly. Since it is desirable for contact readjustment and replacement to be kept to a practical minimum, measurements of contact-material transfer rates were made in the hope of finding a general formula which might be used to predict the material transfer rates for a large number of elements and alloys. Several techniques not generally available to earlier workers in the field were used to measure accurately the arc duration and intensity.

A time-interval meter which could be triggered with the start of the arc and stopped at the extinction of the arc was used to record both single arc duration and accumulative arc duration, as shown in the diagram. As expected, the arc produced in a given circuit was found to vary in duration as the contacts were operated and as they became 'activated' through the formation of surface films. By using an oscilloscope circuit to measure the voltage and current in the arc as a function of time, the authors found it possible to calculate the energy dissipated in the arc and the total charge passed.

Within experimental error, the material transfer from the cathode was found to be directly proportional to the charge passed in the arc, a relationship first proposed by R. Holm. In addition it was found that the cathode-material transfer could be described with reasonable accuracy by a formula first proposed by Llewellyn Jones.

By means of measured material-transfer coefficients it is possible to estimate the life expectancy of contacts operating in a specific application and to compare the various materials with regard to their ability to withstand erosion. Also, the formula of Llewellyn Jones may be used to predict quantitatively the effect of alloying materials for given applications.

The work also illustrated the role played by organic contaminants in increasing the arc duration. The general result of such contamination is to increase the erosion in a given circuit as the contact becomes 'aged' through use. Since the erosion may increase by a factor of ten it is obvious that considerable gains in contact life can be made by control of the contact environment, a factor which is frequently overlooked by the design engineer.



Circuit used to measure the average arc duration

621.316.5.064.43

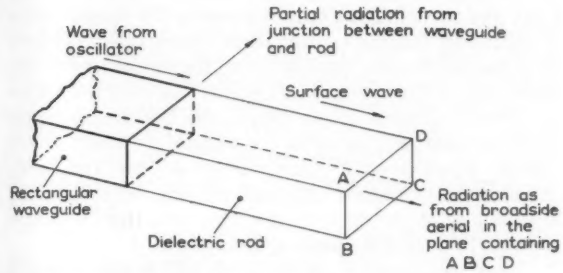
End-Fire Aerials

A short review of a Radio and Telecommunication Section paper (No. 2216) entitled 'The Radiating Properties of End-Fire Aerials', by J. Brown, M.A., Ph.D., Associate Member, and J. O. Spector, Ph.D. The paper is published this month in Part B of the Proceedings.

V.H.F. AND U.H.F. AERIALS ARE USUALLY CLASSIFIED AS broadside or end-fire, according to the direction of radiation with respect to the major dimensions of the aerial. Broadside aerials, of which arrays of half-wave dipoles and paraboloid reflectors are common examples, radiate beams more or less perpendicular to the area of

the aerial. An end-fire aerial on the other hand consists of a structure which is of cylindrical form, and the direction of maximum radiation is along the axis of this cylinder. The well-known Yagi is an example of a v.h.f. end-fire aerial, and a number of types of u.h.f. aerial exist, based on dielectric rods and cylinders. Individually, each of the end-fire aerials has been treated quite extensively, with fair agreement between theoretical and experimental results. There does not appear to have been any general analysis applicable to all end-fire aerials and the paper under review seeks to fill this gap.

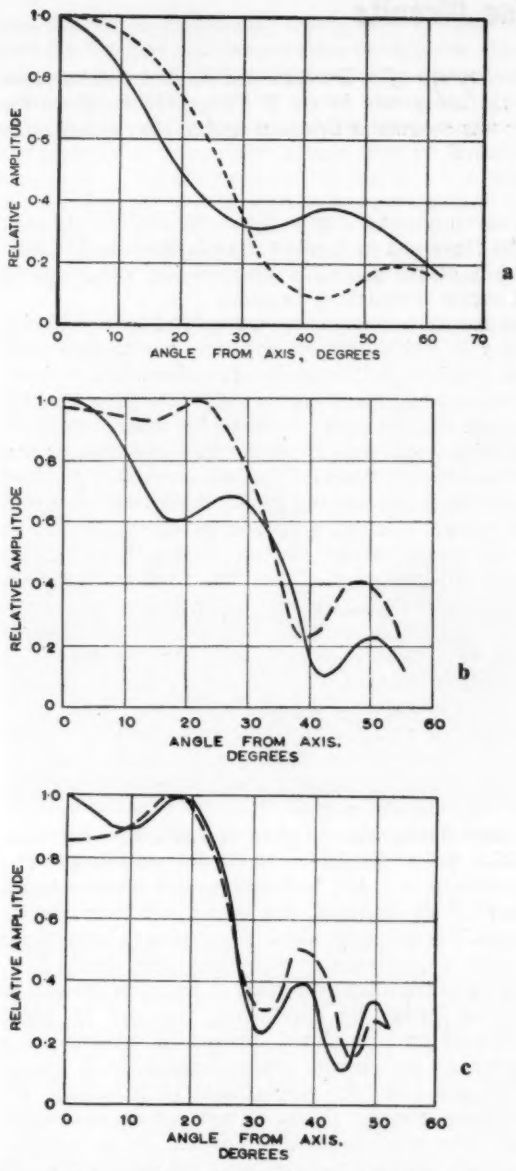
The theory developed by the authors is quite general, and can be easily followed with reference to a specific end-fire aerial such as the dielectric rod sketched in Fig. 1. This consists of a rod of dielectric, either rectangular or circular in cross-section, whose dimensions are such that it can support a surface wave. The surface wave travels along the direction of the rod axis with a phase velocity a little less than that of a plane wave in free space, and, because of the low losses in the dielectric,



1 *Operation of an end-fire aerial*

the attenuation is small. There is no radiation from this wave as it travels along the rod and the electric and magnetic field strengths fall off quite rapidly with increasing radial distance from the axis. At the termination of the rod the surface wave sets up a field in the plane normal to the axis of the rod. This plane can be regarded as the aperture of a broadside aerial, and from the field distribution the radiation pattern can be calculated. Calculations based on this argument show that the beamwidth is strongly dependent on the phase velocity of the surface wave, becoming smaller as the phase velocity approaches that in free space.

Comparison of theoretical patterns calculated as above with measured patterns show considerable discrepancies. This is largely accounted for by the neglect in the calculations of the conditions at the junction between the waveguide and the dielectric rod. The theory effectively assumes that all the available energy travels down the rod as a surface wave. In practice it is extremely difficult to achieve this, and some energy will be radiated directly from the feed, forming a relatively broad beam. The complete radiation pattern of the aerial is formed by interference between the waves radiated from the two ends of the rod. When allowance is made for this,



2 *Radiation patterns for dielectric rods of diameter equal to 0·46 × free-space wavelength*

Experimental patterns are shown in continuous lines; theoretical patterns, calculated on the assumption that 6% of total energy is directly radiated from feed, are shown in broken lines. The lengths of the rods, in free-space wavelengths, are (*a*) 2, (*b*) 4, (*c*) 6.

reasonable agreement between theory and experiment is obtained as shown by Fig. 2.

The paper ends with a general discussion of the theory as applied to various end-fire aerials and shows that most of the experimentally observed results admit of straightforward explanations.

621.396.677

Pulse Circuits

A short review of a Graduate and Student Section paper with the above title by G. A. Gibson, M.A., B.Sc. The paper was awarded a Graduate and Student Premium by the Council.

THE DESIGN OF PULSE CIRCUITS IS BASED MATHEMATICALLY on the Heaviside or Laplace transformation. The construction of pulse circuits involves the use of active components as switching elements.

The first statement can be exemplified by considering the way in which different engineers would consider a circuit consisting of a capacitor in series with a resistor, the output being taken across the resistor. An engineer concerned with the more traditional branches of electrical engineering would describe it as a high-pass filter or as a coupling network, draw its response curve as a graph of gain against frequency, and specify the cut-off frequency. An engineer concerned with radar or other applications of pulse circuits would describe it as a differentiating network, draw a graph of the output against time with a step-function input, and quote the time-constant.

The second statement can be illustrated by comparing the use of a valve in the different types of circuit. In ordinary amplifiers, such as those used in radio, the valve is used as a linear amplifier and the curvature of its characteristic causes distortion. In pulse circuits the valve is normally either conducting hard or cut off, and the curvature of the characteristic is completely swamped in the other discontinuities.

If these statements are taken as definitions, the fields in which pulse circuits are used are very large. The most obvious is radar, including guided missiles and a number of navigational aids which use very similar methods. Another field which is growing in importance at present is computers, both analogue and digital.

The two alternative definitions of pulse circuits can be illustrated further by considering the way in which components are considered. Instead of thinking of a capacitor as an element whose impedance is purely reactive and inversely proportional to frequency, the pulse-circuit engineer thinks of it as an element which satisfies the relationship $I = CdV/dt$. Valves become rather more complex elements since the potentials on all the electrodes can vary simultaneously. This is rather different from applications in radio where normally only two electrodes have significant variations in potential. But each characteristic becomes simplified and is considered as a number of straight-line segments. This is not really a limitation, since a circuit which depends for its operation on the exact form of a characteristic is unlikely to be a satisfactory circuit in production.

The components are then combined into shaping or gating circuits, which in turn can form part of generating or detecting circuits. From these basic blocks the engineer forms his complete equipment.

Shaping circuits are those in which a linear function of the input and its derivatives is equal to a linear function of the output and its derivatives. The basic forms are the differentiating and integrating circuit (usually formed from a resistor and a capacitor in series), the ringing circuit (a parallel-tuned circuit), and the delay line (a number of inductors in series with capacitors from the junction points to a common line). All other circuits consist of several of these basic circuits in series or in parallel. Valves or other active elements are used in this type of circuit either as isolating devices—the cathode follower being a commonly used circuit—or as amplifying devices, when feedback is almost universally used, as in the virtual-earth amplifier, in which the feedback keeps the grid of the valve virtually at earth potential.

Gating circuits are those in which the output is dependent only on the instantaneous values of two or more inputs. In some circuits certain of the inputs are steady potentials. The simplest gates use one or more diodes and give outputs equal to the most positive or the most negative of the inputs. A common refinement is to use two or more cathode followers with a common cathode load, and so obtain an output equal to the most positive of the inputs without loading these inputs. Other methods of gating involve the application of the inputs to different electrodes of one valve. But in all such circuits the output is a linear function of the inputs, the coefficients in the function changing in value at particular values of the inputs. More general relationships do not frequently occur in pulse circuits although they do occur in other branches of electronics, for example with the frequency-changer in a superheterodyne receiver.

Generating circuits are those in which the output is independent of the input, provided that the input exceeds the amount necessary to trigger the circuit. In some circuits it is possible to choose the values of the components so that the amplitude of trigger required is zero. The circuit then becomes an oscillator. A comprehensive classification of all the varieties of generating circuit would be so complex that it would be useless for practical purposes, but an examination of the operation of any such circuit will reveal that there are, in general, three types of state of the circuit: stable states, in which the circuit will remain indefinitely; unstable states, during which positive feedback is in operation and which therefore only occur during transition periods; and quasi-stable states, in which the active elements are operating under constant conditions but the potentials at various points are altering slowly.

Detecting circuits, in which the output is dependent on the value of the input at some previous time, usually consist of a gate followed by a shaping circuit. The shaping circuit, which is used as a means of storage, has a variable time-constant which is altered from one value to the other by the input signal.

Owing to the conflicting requirements on the value of a component it is frequently necessary to add refinements to these basic circuits. One of the most common is the use of a catching diode to set accurately the voltage at some particular point of the waveform. Another technique

which is often of assistance is to obtain the bias for a valve, not by the usual fixed-bias or cathode-bias methods, but by cathode-follower bias or feedback bias. In the first of these the cathode of the valve is returned through a comparatively high-value resistor to a point which is negative with respect to the grid. In the second method there is a resistive path from anode to grid and a resistor from the grid to a negative potential, the cathode being connected directly to earth. Both methods involve the use of a negative voltage supply. Such a supply has many other uses since it enables portions of the circuit to be at a potential suitable for direct coupling. 621.374.3

Television Outside-Broadcast Units

A short review of a Graduate and Student Section paper with the above title by F. H. Steele, B.Sc.(Eng.), Graduate, and K. T. D. Hughes, Student. The paper was awarded a Graduate and Student Premium by the Council.

OUTSIDE BROADCASTING COVERS NOT ONLY FAMILIAR outdoor sporting events but also all indoor events televised away from the studio centre. For this reason, and also because of difficulty in parking the vehicle sufficiently close to the scene, it is necessary to design the unit so that all the equipment may be readily demounted and set up in some convenient place inside the building.

For reasons of economy, it is generally considered desirable to design a range of basic electronic units which may be mounted either in a mobile form for outside-broadcast use, or in consoles and Post-Office-type racks for use in the studio. A typical outside-broadcast unit contains approximately twenty-five electronic units, and the function and requirements of each one must be considered in detail before the vehicle is designed.

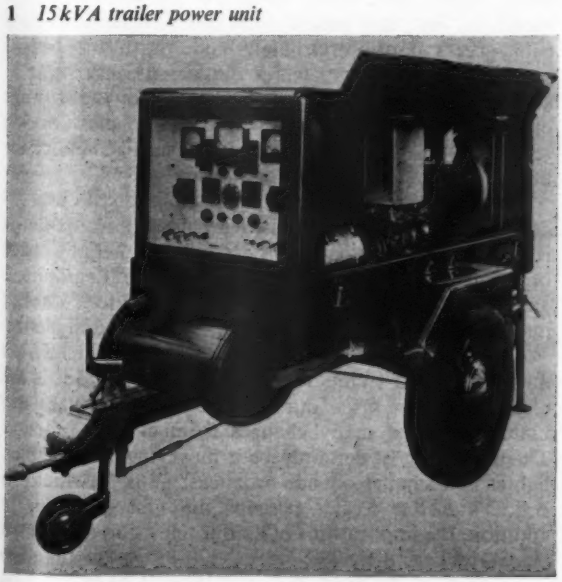
An operational crew of about twelve is required, ranging from the producer and the senior engineer, to the riggers and driver. The vehicle must be so designed that each of the crew can do his job with the greatest speed, efficiency and comfort. A proper appreciation of the roles which each has to fulfil is important.

The number of operating personnel and the quantity of equipment to be carried give rise to a number of design problems, such as (*a*) the provision of a clear line of sight from the production staff to the picture monitors, (*b*) air conditioning and ventilation, (*c*) stowage of cameras, tripods, lenses, cables and cable drums, (*d*) mountings for microwave links and receiving aerials and (*e*) provision for towing a trailer power-unit (Fig. 1). The design must, of course, take into account the normal vehicle restrictions of maximum legal overhang and width; spring, tyre and chassis loadings; engine power and power/weight ratio; weight distribution; chain clearance; lighting regulations and the availability of spares.

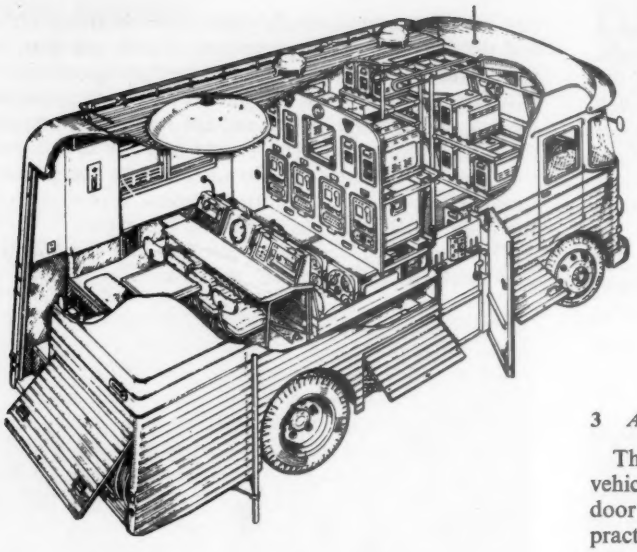
In general a straightforward mass-produced chassis of the type used in furniture vans is chosen. Originally, an articulated chassis was used, but recently preference has been given to the self-propelled vehicle. Body styles over the past few years have been a compromise between expensive streamlining and austerity, and the aim of the designer must be to avoid complex curves and yet maintain an attractive appearance, as shown in Fig. 2.

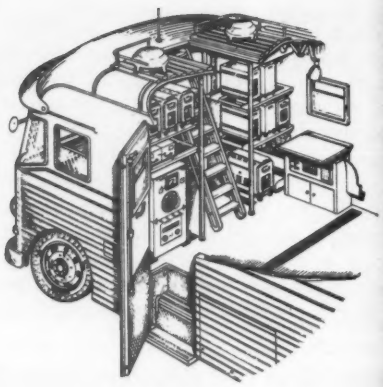
A typical modern vehicle (Fig. 3) is divided into three sections, the production area, the servicing area and the cab. There are three camera-control units which are arranged in a row side by side, each having its own

1 *15kVA trailer power unit*



2 *Typical outside-broadcast unit complete with vision and sound microwave links, and a trailer power unit*





3 *A modern television outside-broadcast unit*

monitor. A fourth monitor is provided for use of the producer and is operated by preview switches on the vision mixer panel. A radio check receiver is mounted centrally and above the camera-control position. A well at the rear of the vehicle, covered by a raisable flap, houses the camera cable and mains cable drums. The air-conditioning plant is mounted in the space between the rear wheels and the back entry stairs, the air being led in ducts up the wall of the production area and expelled at high level. Air returns to the plant through grilles in the riser of the top step.

The production area is separated from the rest of the vehicle by a full-width bulkhead with a communicating door in the gangway to the servicing area. It is current practice for the outside-broadcast unit to house three camera channels of the type shown in Fig. 4. When the vehicle is in transit, the bottom third of the bulkhead hinges down, and the cameras are carried at the centre of the pitch of the vehicle on suitably designed shock mounts. The non-operational units (power supplies, synchronizing generators, communication units, automatic voltage regulator, etc.) are mounted in racks forward of the servicing area. Four axial-flow fans in the servicing area draw fresh air through louvres in the floor and expel the heated air through a rain-proof aperture in the roof. A trapdoor giving access to the roof is provided in the corridor between the servicing area and the cab. This permits either a camera or a microwave link to be mounted on the roof when necessary.

In operation, the mains and camera cables, utility outlet cables and vision feeds for the commentator's monitors, etc., are passed into the vehicle through a cable-access door immediately underneath the hinged servicing flap. The cab has a double-passenger seat in addition to the driving seat, and is fitted for the stowage of personal belongings of the production crew during rehearsal and transmission. All available space under the floor of the vehicle is used for stowage.

Although the television outside-broadcast unit is designed primarily as a mobile television control-room, it is a regrettable fact that a considerable number of outside broadcasts call for the equipment to be demounted, and the problems which then arise have to be taken into consideration when the vehicle is being designed.

As with everything in television the design of television outside-broadcast units is a compromise. New ideas are constantly being tried out and the next few years will undoubtedly see many changes from current practice. There will almost certainly be a move towards simpler, lighter and smaller outside-broadcast units of which the B.B.C.'s *Roving Eye* is perhaps the first example. In addition, the implications of colour television should not be overlooked.

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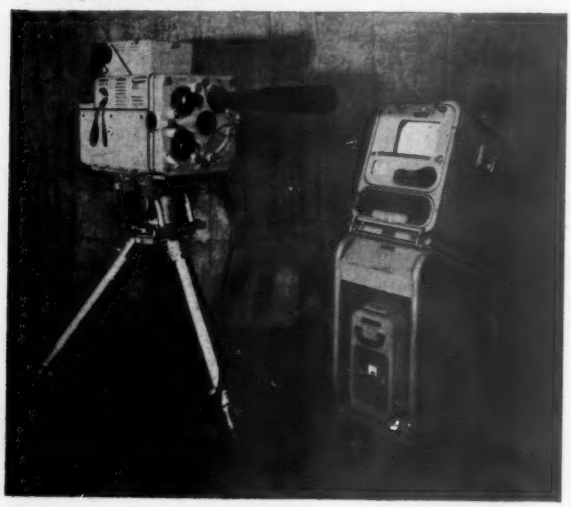
4 *Typical camera channel*

This comprises five basic electronic units—the camera, the electronic viewfinder, the camera control unit, the picture and waveform monitor, and a regulated power-supply unit which feeds the complete camera chain.



Sound Recording

A short review of a Graduate and Student Section paper entitled 'High-Fidelity Sound Reproduction', by S. L. Hurst, B.Sc.(Eng.), Graduate. The paper was the Chairman's Address to the Bristol Graduate and Student Section, delivered at Bristol on the 12th October 1955, and it was awarded a Graduate and Student Premium by the Council.

IN THE TECHNOLOGY OF RECORDED SOUND, THE SEARCH for higher fidelity has made great strides in recent years, and the two principal systems used to-day, namely the magnetic-tape recorder and the disc gramophone, are both capable of very high quality reproduction, covering the whole frequency spectrum to which the human ear is attuned, that is from about 30 c/s to around 15 kc/s.

The Magnetic-Tape Recorder

The principles of magnetic-tape recording are by now widely appreciated. The magnetic tape is magnetized by a magnetomotive force from the recording head, and the small open-circuit permanent magnets thus produced on the tape induce corresponding amplitude and frequency voltages in the replay head, when the tape is passed over the latter. The signal from the replay head can be amplified and fed into loudspeakers in the usual manner.

Owing, however, to the non-linearity, about the origin, of the *B*|*H* characteristic of the magnetic coating of the tape, it is not sufficient to feed the recording head with a signal corresponding only to the audio input, and a signal comprising the audio input superimposed on a high-frequency bias is employed. By removing this high-frequency component from the replay-head output signal, the output remaining is a faithful copy of the original audio input.

The h.f. bias must, of course, be above the limit of audibility, and frequencies in the range 25–50 kc/s are commonly employed. The same frequency is generally and conveniently employed to erase previous recordings on the tape, the pure h.f. signal being fed to an erase head as and when required.

The mechanical details of a tape recorder must be of good design and workmanship, in order to do justice to the potentially high performance available from this recording medium. Tape speed must be kept constant and free from random variations, and tape tension must also be carefully maintained to ensure satisfactory winding off from and on to the two tape spools. Three motors are often employed to achieve the above requirements, a master or capstan motor to drive and govern the speed of the tape, and two others, one per tape spool, to give tension on the tape before and after the capstan drive.

The Disc Gramophone

The disc gramophone is the most well known of all forms of recording, though probably the performance of the majority in domestic use does not exhibit the true possibilities of this form of reproduction.

In cutting the master disc from which all copies of the record will stem, the cutting stylus is caused to oscillate laterally, that is from side to side about the mean groove path on the record. The actual displacement/frequency characteristic of the groove varies somewhat between different recording companies, and with the type of record, but generally the characteristics are such that (*a*) the average lateral velocity of the cutting or tracking stylus decreases with decrease of frequency below a certain nominal frequency, and (*b*) increases with frequency above a second higher frequency. The former is necessitated by the fact that a constant lateral velocity of oscillation cannot be maintained below a certain frequency without large lateral deflections of the groove and consequent uneconomically large groove pitch, whilst the latter is desirable because, on reproduction, the attenuation of the resultant increased higher frequencies tends to reduce to tolerable proportions the surface 'scratch' noise, which is itself a wide-band high-frequency source.

Whatever recording characteristics are employed, final overall linear response can be achieved by means of suitable bass and treble equalization circuits in the pre-amplifier, these circuits also giving appropriate correction for the output characteristics of the pick-up employed. The three principal types of pick-up, namely moving-coil, moving-iron (or variable-reluctance) and piezo-electric-crystal pick-ups, exhibit different output/frequency characteristics, the output of the first two electromagnetic types basically increasing with frequency, and the output of the piezo-electric type being basically independent of frequency.

The duty of the pick-up stylus in tracking a record is extremely arduous, especially on modern long-playing records with treble pre-emphasis. The acceleration of the stylus tip in following the lateral groove displacements may reach values as high as 1 000–2 000 g, and for the stylus to be accelerated at such rates, it is apparent that the effective mass of the stylus must be made as small as possible. All good modern pick-ups have therefore highly compliant styluses, and the effective stylus mass, that is the equivalent mass to be accelerated by the groove displacement, may be as low as 3 mg.

As with the tape recorder, the mechanical details of the gramophone must be of high quality for optimum results. The turntable, uusally driven by a four-pole synchronous or induction motor via intermediate rubber-tyred wheels and/or rubber belts, must rotate at an absolutely uniform speed, and to this end, is often made of considerable weight. The motor and intermediate wheels are, in addition, usually floated on rubber or spring suspensions to minimize the transmission of motor vibration to the turntable.

Loudspeakers

The loudspeaker is one of the weakest links in the chain of items constituting the recording and replaying system. The function of the loudspeaker is to convert its electrical input into sound waves of amplitude and

frequency corresponding to the original, but owing to the inertia of the moving members of the loudspeaker, and also to its natural resonance, exact correspondence is impossible to achieve.

With the normal cone-type speaker, it is desirable to keep the coil and cone assembly as light as possible, and also the cone as rigid as practicable. The former requirement reduces the inertia of the moving members, whilst the latter helps to prevent the cone breaking up into harmonic oscillations along its length.

The electrostatic speaker possesses the inherent advantage that the driving force on the diaphragm is distributed over its surface and not concentrated at one point, as in the cone-type speaker. It consists basically of a very thin light metallic-coated diaphragm mounted between two perforated metal plates. The diaphragm is electrostatically 'push-pulled' by the audio voltage between the two plates, being itself held at mid-potential. The further advantage of this type of speaker is that the diaphragm can be made very thin and fragile, and its inertia correspondingly small, thus ensuring good audio response to high frequencies and transients. 621.395.62

Papers read at the Convention on Electrical Equipment of Aircraft, May 1956

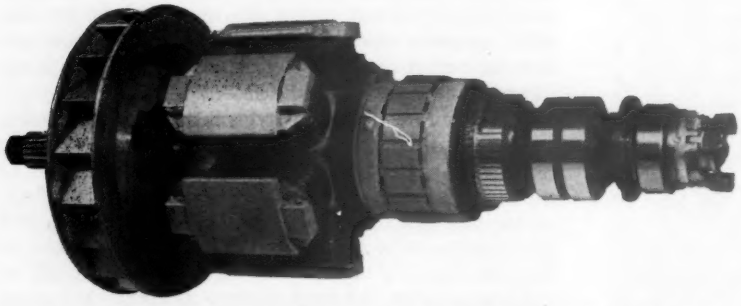
The following are short reviews of the remaining papers read at the Convention on Electrical Equipment of Aircraft, which was held by The Institution from the 2nd to 4th May 1956. The first selection was published last month. The complete papers were published in December 1956 in a special supplement to Part A of the *Proceedings*, as announced in the *Journal* for September 1956, p. 567.

Excitation Systems

Paper No. 2133 entitled 'Excitation Systems for A.C. Aircraft Generators', by N. C. Adcock, Associate Member, and A. W. Ford, B.Sc.(Eng.), Associate Member.

THE PAPER REVIEWS VARIOUS METHODS OF EXCITING A.C. aircraft generators, and discusses their relative advantages and limitations in the light of present and future design requirements.

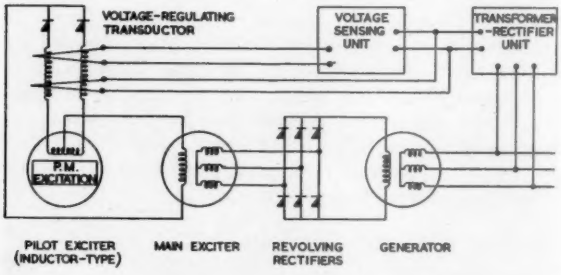
One of the most common methods of exciting a.c. generators is by means of a d.c. exciter built in as an integral part of the generator. A typical example is illustrated in Fig. 1, which shows the rotor of a 9 kVA alternator with the exciter armature mounted on the shaft. It is well known that d.c. exciters are subject to voltage instability at the lower end of the working range, and sometimes to loss of voltage or to polarity reversal after sudden load changes or fault conditions. Also, in spite of intensive research, the problem of preventing rapid brush wear on commutators and slip rings at high altitude still awaits a satisfactory solution.



1 *Rotor of 9 kVA alternator with d.c. exciter armature mounted on rotor shaft*

It is suggested that the excitation requirements of present and future high-speed high-altitude aircraft generators will best be met by built-in a.c. exciters designed for 1 600 c/s or 2 400 c/s, supplying the generator field through rectifiers.

With the advent of silicon rectifiers sufficiently small, light and robust to be mounted on a high-speed shaft, it becomes possible to eliminate all sliding contacts from the excitation circuit. A typical arrangement embodying these features is shown in the schematic of Fig. 2. 621.313.33



2 *A.C. generator with a.c. exciter and permanent-magnet a.c. pilot exciter*
Rectifiers mounted on rotor shaft.

Aircraft Electrical Cables

Paper No. 1994 with the above title by D. W. Bird, B.Sc., D. C. Hancock, B.Sc., Ph.D., F.R.I.C., and D. B. McKenzie, B.Sc., Member.

WITH THE INCREASING COMPLEXITY OF MODERN AIRCRAFT the total length of cable has been increasing, until to-day

many miles are installed in a large aircraft and many special cables are required to meet the various environmental conditions. The complexity of the wiring is illustrated in the photograph.

In early aircraft, the only cable used was for engine ignition, but instruments and lights soon required other cables, which were similar to those used for domestic wiring purposes. As these cables were liable to deteriorate rapidly in contact with petrol and oil, special aircraft cables were developed. Improvements followed with the increased severity of service conditions, until the present-day standard general-service cable, the Pren type, was produced.

The Pren cable consists of a stranded tinned-copper conductor and glass-fibre braid, over which is a layer of polychloroprene (p.c.p. or Neoprene) synthetic rubber compound. Introduced in 1947 this is now the most commonly used aircraft cable in Great Britain and has proved satisfactory in a wide range of aircraft. Although polychloroprene has a lower volume resistivity than other dielectrics used in aircraft cables, it is adequate electrically for its intended purpose. It is on account of the following particular physical characteristics that the rubber-like polychloroprene is the preferred general-purpose insulation:

(*a*) Flame resistance.
(*b*) Resistance to fuels, common lubricants and most hydraulic fluids.
(*c*) Ability to withstand deformation forces at elevated temperatures.

The glass-fibre braid beneath the polychloroprene insulation has two functions. First, and most important, it provides an electrically insulating inorganic spacer, thereby permitting the cable to function for a limited time during or after a fire even though the polychloroprene may become charred. Secondly, the combination of the glass-fibre braid and polychloroprene provides a higher insulation resistance than it is possible to achieve with polychloroprene alone, especially at elevated temperatures.

Typical aircraft installation

On the larger sizes of Pren cable, a considerable saving

Power-Supply Cables

Type	Specification	Construction		Working temperature* range	Application and special merits	Limitations
		Conductor	Insulation			
Pren	B.S. E21	Tinned copper	Glass braid and polychloroprene	−30° to +90°C †	Normal duty in aircraft	Attacked by ester-base fluids
Prenal	B.S. E21	Aluminium	Glass braid and polychloroprene	−30° to +90°C †	35 amp circuits and above, where weight saving can be achieved	Attacked by ester-base fluids
Nypren	M.O.S. (Air) EL.1771	Tinned copper	Glass braid and polychloroprene with (*a*) nylon sheath or (*b*) nylon braid and lacquer	−30° to +90°C †	General-purpose cable where there may be contact with ester-base fluids	
Glasil	M.O.S. (Air) EL.1622	Tinned copper	Silicone rubber, asbestos and glass braid	−75° to +150°C	Hot situations where Pren cable is inadequate	Poor resistance to kerosene
Unief and Glasef	M.O.S. (Air) EL.1623	Nickel-coated copper	P.T.F.E. (with glass braid for Glasef)	−75° to +220°C	For use at ambient temperature of 200°C where synthetic fluids may be encountered	High cost
Unifire red	M.O.S. (Air) EL.1736	Nickel-coated copper	Glass braids and asbestos. Finished with glass braid and lacquer	−30° to +150°C †	Fire-detector circuits and where cable is required to function during or after a fire	Unsuitable for circuits above 30 volts

* The maximum value of the temperature range includes the temperature rise of the conductor above that of the ambient temperature.
† −75°C in static locations.

in weight can be achieved by the use of aluminium conductors, and a range of such cables is available, known as Prenal cables.

With the introduction of ester-base lubricating oil into aircraft gas-turbine engines, an additional protection for the Pren cables was necessary and this has been obtained by the application of a thin nylon sheath or nylon-lacquered nylon braid over the polychloroprene; these are named Nypren cables.

Pren and Nypren cables are suitable for use up to a maximum temperature of 90° C but certain circuits on a modern aircraft are frequently exposed to higher temperatures. For use up to 150° C a silicone-rubber-insulated cable has been designed, known as Glasil cable. For temperatures up to 250° C a cable insulated with polytetrafluorethylene (p.t.f.e.) has been developed and is used quite extensively in modern aircraft. This cable is known as Unief or Uniglasef, the nomenclature depending upon the detail construction used.

Certain circuits have to function during or after a fire, and for this application the cable consists of a stranded nickel-coated copper conductor insulated with glass, asbestos and silicone compound and finally lacquered with a non-inflammable red dope. This cable will withstand 5 min exposure to a standard flame at a nominal temperature of 1 100° C. It is known as Unifire red cable.

Details of these power-supply cables are given in the table.

The current rating of the power-supply cables is governed primarily by the maximum temperature which the insulation will withstand without significant damage or deformation, but from the operating aspect of equipment the voltage drop in the cable is generally the limiting factor. There are many variables influencing the rate of flow of heat from the conductor, namely the thermal conductivities of the insulation and sheath of the cable, the size and position of cables formed into a bunch, the size and tightness of the bunch, the electrical loading of the cables and the flow and ambient temperature of the air surrounding the cable.

Several other types of special cable are used on aircraft, including engine ignition and igniter cables, compensating and thermocouple cables, equipment wire, cables for the interconnection of instruments and electronic equipments and radio-frequency cables.

It is anticipated that future large aircraft will require more electrical power, probably on a 208-volt 3-phase 400 c/s system, with a few special circuits operating at 2 400 c/s, instead of the present 28-volt d.c. supply. This will present no additional problems from the cable aspect, but with the increase in speed, the aircraft ambient temperature will rise due to kinetic heating. It is anticipated that the general-service cables in these aircraft may have to operate in an ambient temperature of 200° C and special circuits, for instance in the vicinity of the engines, may be in an ambient temperature approaching 400° C. The present range of p.t.f.e. cables will meet the first of these requirements, but development work is necessary to reduce the weight and size of the cables. For the 400° C zones, cables are likely to have metallic sheaths with either glass and asbestos insulation, as in the Unifire red cable, or mineral insulation.

With each new development in aviation, cable requirements become more stringent, and in order to meet these demands new materials are required for certain applications. If these are to be forthcoming, then a considerably greater effort must be made to develop them.

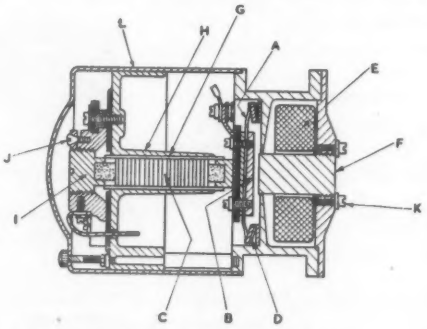
621.315.2 : 629.135

Voltage and Frequency Regulators

Paper No. 2054 entitled 'The Development of Voltage and Frequency Regulators for Aircraft Electrical Systems', by C. W. Cooper, B.Sc.(Eng.), Graduate.

THE PAPER SURVEYS THE DEVELOPMENT OF AIRCRAFT voltage and frequency regulators, as aircraft generating equipment progressed from third-brush d.c. machines to constant-frequency alternators.

Generator driving systems are reviewed, including the use of windmills of both constant and variable pitch. In 1928 tests were made on a generator driven by a gas turbine fed from the exhaust gases of the aircraft engine. Soon afterwards generators driven through gearing from the aircraft engines rapidly ousted the other systems, and nowadays variable-ratio gears enable alternators to be driven at constant speed from the main engines.

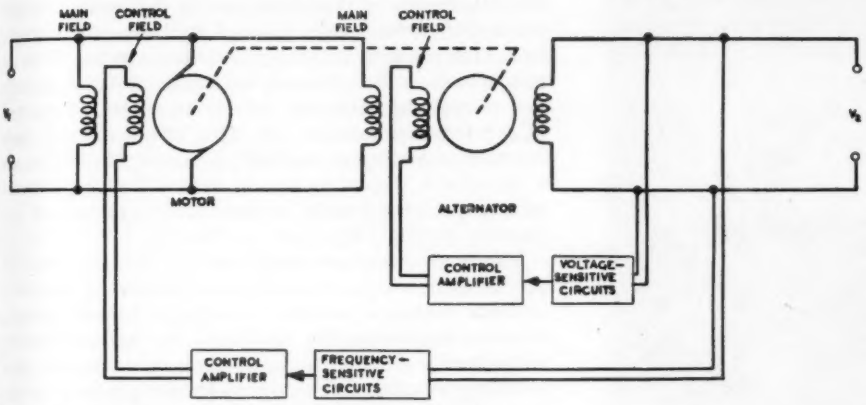


1 *Newton carbon-pile regulator*

A—Spring. B—Armature. C—Carbon pile. D—Bimetallic ring. E—Control coil. F—Core adjustment. G—Ceramic tube. H—Light-alloy casing. I—Compression plug. J—Locking screw. K—Locking screw. L—Cover.

The early third-brush d.c. generators were soon found to be unsatisfactory because of their constant-current characteristics, and they were superseded in about 1929 by shunt-wound machines with Tirrill voltage regulators. Other systems which were tried from 1925 to 1936 included the automatic rheostat regulator, the dynamo-electric regulator and the self-regulating generator system. An account of these systems is given and their advantages and limitations are pointed out.

In 1936 a light-weight voltage regulator of the carbon-pile type was tested for use in aircraft electrical systems. In developed form this instrument became the first carbon-pile regulator to be used in Service aircraft. It was the forerunner of the regulators used in large numbers throughout the Second World War in British aircraft, and in American aircraft from about 1943. Both the Stone and Newton types of carbon-pile regulator (Fig. 1) are described in some detail, together with improvements resulting from development in both Britain and America. The dynamic characteristics of these regulators were studied, particularly in America, and this led to the derivation of transfer functions for the regulators, which could be used in regulating system design.



2 *Block diagram of control system for motor-alternator*
$V_1 = 28$ volts d.c., $V_2 = 115$ volts, 1 600 c/s.

As multi-engined aircraft came into common use, increasing attention was paid to the problems of operating generators in parallel. The simplest arrangement for parallel operation is described, and it is shown how the permissible range of accumulator voltage set a practical limitation on the system. When 6 kW engine-driven generators were introduced in British aircraft the master-regulator system was employed. In this system the master regulator controlled the common busbar voltage through slave regulators which controlled the voltages of individual machines.

In forecasting the lines of future development of the carbon-pile regulator, reference is made to hermetic sealing and the use of control amplifiers. Amplifiers employing transductors or transistors have the advantage of being rugged and compact.

When rotating machines were introduced for the conversion of direct to alternating current, the carbon-pile regulator was employed both as a voltage regulator and as a frequency regulator. As a voltage regulator the carbon-pile was used to control the current in a field winding on the alternator section of the inverter, while frequency regulation could be achieved by controlling the field current in the motor section of the machine.

Electronic amplifiers have been employed in recent years for the control of auxiliary field currents in inverters where high accuracy of frequency and voltage control was required. In 1944 a magnetic amplifier was used to control the frequency of a motor-alternator in the German V2 long-range rocket. The success of this unit drew attention to the advantages of magnetic amplifiers for the control of aircraft inverters. Examples of recent practice in regulator design using electronic and magnetic amplifiers are described, and it is suggested that developments in the field of semi-conductor devices may largely overcome the disadvantages in size and weight of regulating systems employing control amplifiers. A block diagram of a control system is shown in Fig. 2.

Voltage-regulating systems for engine-driven alternators employed carbon-pile regulators similar in design to those used in d.c. systems, but the introduction of constant-frequency a.c. systems posed fresh problems in voltage and frequency regulation. Brief descriptions are given of an American constant-frequency system employing a hydraulic drive, and a British system employing air turbines to drive the alternators.

In conclusion reference is made to the increasingly difficult environmental conditions in which regulators must work in modern aircraft, and to the problems of heat dissipation.

621.316.722 : 621.316.726 : 629.135

High-Altitude Circuit-Breakers

Paper No. 1935 entitled 'D.C. Circuit Interruption and Arc Characteristics at Low Air Pressures', by A. H. M. Arnold, D.Eng., Ph.D., Associate Member, and L. H. Ford, M.Sc.(Eng.), Associate Member.

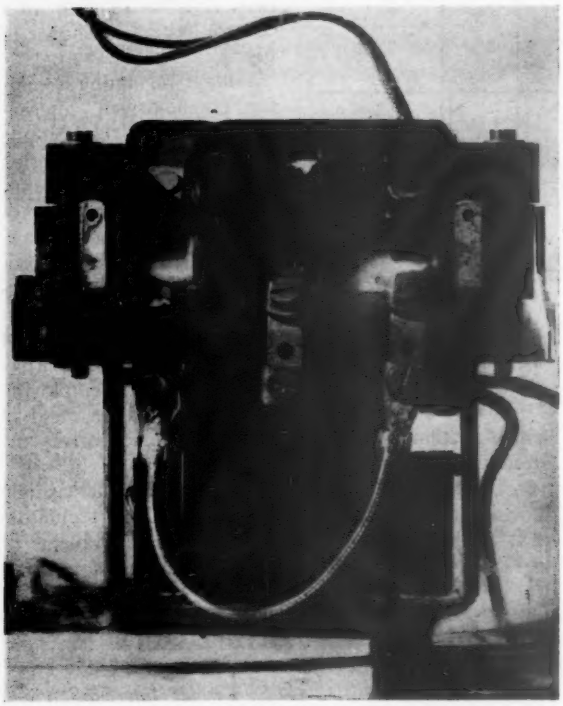
THE DESIGN OF SWITCHES AND CIRCUIT-BREAKERS FOR aircraft grows more difficult as the altitude of flight becomes greater; this is because the arc voltage, under defined conditions of arc current and gap length, decreases as the air pressure is reduced. An empirical formula which has been derived from a large number of experiments, gives the voltage V of a d.c. arc between silver electrodes in air at a pressure of P mm Hg:

$$(V - 12)^3\left(I^3 - \frac{2}{\sqrt{P}}\right)^{1/3} = 3000\, l^{3/2} P^{1/3} \quad . \quad (1)$$

where l is the gap length in millimetres and I the arc

current in amperes. This formula is satisfactory for values of P greater than 20 mm Hg, but below this pressure the arc voltage appears to have two possible values according to the time that has elapsed from striking the arc. The performance of a switch at any given altitude may be predicted by drawing tangents to the arc characteristic derived from equation 1 with the appropriate values of P and l inserted.

The difficulty of current interruption at low air pressures may often be overcome by increasing the gap length of a switch, but at the lowest air pressures the gap length required is likely to be excessive; the use of a number of gaps in series then becomes a preferable alternative. If N is the number of series gaps of given



Interruption of 110-volt 100amp d.c. circuit at a pressure of 1 mm Hg

length required in a switch to break a given current successfully at a pressure P and a circuit voltage V_c, and N_a is the number required to break the same circuit at atmospheric pressure P_a, then

$$\frac{N}{N_a} = \left(\frac{P_a}{P}\right)^{1/9}\left(\frac{1 - 12N/V_c}{1 - 12N_a/V_c}\right)^{4/3} \quad . \quad . \quad (2)$$

Thus the number of series gaps required at any air pressure greater than 1 mm Hg is never more than twice the number required at atmospheric pressure.

Numerous tests on the interrupting capacity of switches on d.c. circuits have shown reasonable conformity with the performances predicted from equations 1 and 2, over the range of air pressure 760–1 mm Hg. The photograph shows the successful interruption of a 110-volt 100 amp circuit having a 3 millisec time-constant, by a switch with four gaps in series each 10 mm long, at an air pressure of 1 mm Hg; it shows clearly the large spread of the arc at low air pressures, which must be guarded against by effective barriers between adjacent pairs of contacts.

When the circuit current to be broken is small, so that the performance of the switch may be determined by the arc characteristic in the region of minimum arc current, circuit interruption at low air pressures is as simple as at atmospheric; this is because the value of the minimum arc current increases as the air pressure is reduced ($2/\sqrt{P}$ term in equation 1). This effect is very pronounced with tungsten contacts; for example a switch on a 70-volt d.c. circuit broke a current of 7 amp at atmospheric pressure and a current of 11 amp at an air pressure of 10 mm Hg.

The performance of copper contacts cannot easily be predicted from an arc characteristic because the presence of oxide greatly affects the arc voltage. At atmospheric pressure arcs cause the electrodes to oxidize rapidly; consequently it is difficult to obtain an arc characteristic referring to oxide-free copper. At air pressures lower than about 50 mm Hg arcs tend to remove oxide from the electrodes, and it is equally difficult to obtain an arc characteristic referring to oxidized copper. Performance tests on similar switches showed that used copper contacts are slightly inferior to silver in arcing properties at about atmospheric pressure, but may be slightly superior at air pressures lower than 100 mm Hg.

621.316.5.064.2 : 621.3.014.31

Aircraft Batteries

Paper No. 2110 entitled 'Aircraft Batteries and their Behaviour on Constant-Potential Charge', by G. A. Earwicker.

A BRIEF SURVEY OF THE PRESENT STATE OF PROGRESS in aircraft battery development is given, followed by a discussion of constant-potential charging as it applies to aircraft practice. Improved high-rate performance and increasingly unfavourable working conditions have made aircraft batteries over-sensitive to excessive busbar voltages. The variables affecting battery stability are discussed and illustrated by examples from modern batteries. It is shown that with lead-acid batteries a worth-while improvement would be achieved if antimony could be eliminated. This change would not merely reduce the incidence of boiling but should greatly improve overall reliability, ease of servicing and tolerance towards high ambient temperatures without increasing complexity.

621.355.163 : 629.135

Design Considerations

Paper No. 2115 entitled 'Aircraft Electrical Installation Design', by C. C. Jackson, Associate.

THE PAPER IS A BROAD SURVEY OF THE DESIGN AND installation of electrical systems as an integral part of, and peculiar to, the aeroplane.

The requirements for aircraft systems are generally more severe than for commercial power systems, and strict compromise between weight and performance must be maintained. Far more use is made of special materials and cooling arrangements, and each pound of weight carried has a monetary value, the amount depending upon the rate of utilization, an instance being quoted showing this as high as £65 per pound over a year's operation.

The operating conditions to which equipment is subjected cover a temperature range of −75° to +55° C, a vibration range of 10–500 c/s, resistance and altitude effects, and acceleration and deceleration during aircraft manoeuvres of up to 10*g*. These conditions may be experienced on any one flight through the full range, and stringent control is necessary during manufacture and testing of the components and system to ensure that these conditions are met successfully.

The generating system is subjected to extensive testing by both electrical and aircraft manufacturer prior to installation in the aircraft, and the aircraft manufacturer may also assemble the distribution system on the test rig as shown in Fig. 1. Operational experience is accumulated from aircraft operators' route trials, and items of equipment are continually scrutinized before being finally passed for service.

1 *Assembly of an aircraft distribution system*
Loading-mat assemblies are used where multiple loads are encountered.

2 *Part of main distribution panel*

Recommended operating voltages for primary electrical power are 28 or 112 volts d.c., and 3-phase 200 volts a.c., and the paper refers to the loading requirements in their relation to size and range of the aircraft and its proposed duty. Strict economy must be observed in plotting power supplies, and the paper gives a detailed electrical-load analysis with the appropriate operating times and conditions. A number of faults experienced in operational aircraft are described, which typically illustrate the vulnerability of aircraft equipment to operating conditions, and details of some remedial measures are given.

During the construction of the aircraft the technique of sub-assembly is adopted, the electrical system being suited to this form of manufacture, particularly cable looms and distribution panels (Fig. 2). A replica of the aircraft is constructed and used as an

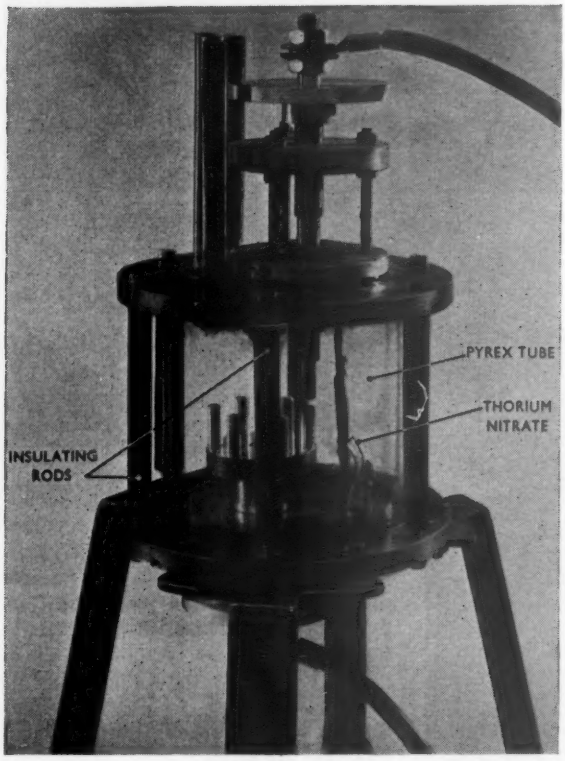
assembly check structure, the parts being transferred to the aircraft on completion.

The tempo of modern development is increasing, and it is hoped that more graduate electrical engineers and physicists will be encouraged to enter the field of aircraft electrical engineering. 621.311.28 : 629.135

Characteristics of Stable D.C. Arcs

Paper No. 2042 entitled 'The Current and Voltage Relationships of a Stable D.C. Arc between Copper and Silver Electrodes in Air at 1–760 mm Hg', by I. A. Mossop, B.Sc.Tech., and F. D. Gill, B.Sc.(Eng.).

A METHOD HAS BEEN DEVELOPED FOR MEASURING THE characteristics of a stable d.c. arc in which the effects of moving electrodes have been eliminated. By making



General appearance of the arcing chamber

measurements only after the arc has become stable, oscillographic film methods are unnecessary, and in their place has been substituted a technique using peak voltmeters. These are switched into the circuit after the arc has become stable, and an automatic sequence controller then disconnects the measuring equipment and extinguishes the arc. The duration of the arc is thereby kept short and electrode wear kept small. The electrodes are stationary during the measurement, the gap being broken down initially by a high-voltage capacitor discharge. The arcing chamber is shown in the photograph.

This research is part of a general programme of investigation of the effects of reduced gas pressure on the behaviour of an arc. The paper gives the results for copper electrodes in air in the pressure range 4–760 mm Hg at currents ranging from 1 to 17 amp for gaps up to 2 mm in length; and for fine silver electrodes in air at pressures of 1–760 mm Hg, at currents of 1–20 amp for gaps up to 2·5 mm in length. The final results are displayed as nomographs.

At pressures less than approximately 50 mm Hg the voltage drop in the arc column becomes small compared with the voltage drops at the electrodes, so that it is then possible to maintain an arc at a voltage very little in excess of the minimum arcing voltage for the electrodes.

Problems of circuit interruption using these and other electrode materials have been investigated separately by Arnold and Ford as part of the same programme of work. 621.317.6 : 621.3.014.31

Future Trends

Paper No. 2091 entitled 'Future Trends in Aircraft Electrical Systems', by D. C. Flack, B.Sc.(Eng.), Ph.D., Associate Member.

AN ATTEMPT IS MADE TO DEVISE THE COMPLETE ELECTRICAL system of a hypothetical civil transport aircraft, based upon the generation, utilization and distribution equipment available at the present time, or likely to be available in the immediate future. The approach used is that of an aircraft constructor's design team, and weight is used as the first criterion. Relative reliability is always more difficult to establish, but in certain kinds of equipment it becomes an overriding factor.

From the assessment, and a very brief examination of existing bomber and fighter aircraft, it is apparent that before deciding upon an electrical system the particular aircraft must be considered in detail. Certain broad conclusions are, however, drawn about the desirability of certain types of utilization equipment and particular generation schemes. Of perhaps more importance are the items of equipment which are deficient in themselves, or which are limiting factors in the future development of the electrical system as a whole. An attempt has been made in the paper to indicate such items and to suggest the direction of their future development. 621.31: 629.135

Electrical System Characteristics

Paper No. 2088 entitled 'Electrical Characteristics and Protection of Aircraft Power Systems', by K. J. Payne, B.Sc.

THE STEADY-STATE AND TRANSIENT CHARACTERISTICS OF the utilization and power-source equipment connected to the aircraft busbar can be used to determine the response of the system to shock loading and the nature of its subsequent recovery to normal conditions. The effect of the resulting busbar disturbances on connected load can then be predicted, and limits determined for maximum permissible excursion from the controlled values.

Protection of the system against generally accepted fault conditions can be achieved by a variety of types of circuit-breaker and protective circuit, the characteristics of which require to be correlated to give a co-ordinated system. 621.311.28 : 621.316.9 : 629.135

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* which have not been read at an Institution meeting and which have not been described under 'Short Reviews of Papers'. They are included here primarily for reference. The papers have not been published individually, as those for reading at meetings, but reprints of them will be available shortly (see p. 36).

F.M. Distortion

A synopsis of a Radio and Telecommunication Section paper (No. 2196) entitled 'Frequency-Modulation Distortion in Linear Networks', by R. F. Brown, B.Eng. The paper is published this month in Part B of the Proceedings.

THE PROBLEM OF DISTORTION OF FREQUENCY-MODULATED waves by 4-terminal linear passive networks has become of increasing importance with the development of multi-channel f.m. communication systems. The paper surveys the somewhat confusing historical background of this subject and after discussion of some essential basic concepts presents a detailed analysis of the problem of small-order distortion. An attempt has been made, using the work of Medhurst, to present the results in a form suitable for computer programming.

Special attention is given to networks which satisfy the minimum-phase condition, because thereby distortion becomes expressible in terms of the amplitude response alone. The results show in a visual yet quantitative manner the error involved in the use of the quasi-stationary solution. 621.376.3 : 621.372

A Non-Resonant Waveguide Window

A synopsis of a Radio and Telecommunication Section paper (No. 2242) with the above title by A. E. Barrington, Ph.D., B.Sc.(Eng.), Associate Member, and J. T. Hyman, B.Sc.(Eng.), Graduate. The paper is published this month in Part B of the Proceedings.

FROM SIMPLE WAVEGUIDE THEORY IT IS SHOWN THAT THE characteristic wave impedance of air-filled (or evacuated) and dielectric-filled waveguides of equal cross-section propagating E-modes can be matched for any free-space wavelength and relative permittivity of the dielectric. For low-permittivity dielectrics, reflectionless transmission may be obtained for a bandwidth of 20%. It is possible to design a waveguide window on these lines, the thickness of which—unlike that of the resonant-iris window—is not critical. The simplicity of the structure appears suitable for high-power microwave valves. A universal design-chart is derived from which the window diameter for the matched condition may be read off directly for any free-space wavelength and relative permittivity of the dielectric. A window design with broad-band mode-transformers is described. 621.372.834

Ship Stabilization

A synopsis of a Supply Section paper (No. 2240) entitled 'Ship Stabilization: Automatic Controls, Computed and in Practice', by J. Bell, M.Sc., Member. The paper is published this month in Part B of the Proceedings.

THE PAPER RELATES IN BRIEF THE DEVELOPMENT OF THE control apparatus by the author for the Denny–Brown type of ship stabilizer from the initial on-off control, to the present proportional control using roll and roll-velocity functions. The use of roll acceleration and a feedback control are also discussed.

Predictions of the performance of a stabilizer by step-by-step and analogue methods are given, the functioning of the analogue computer is described and examples of results are included. Some practical results from sea experience and a brief account of the stabilizing demonstration given during the lecture also appear.

621–52 : 629.123

OBITUARY

LABOUCHERE HILLYER BAINBRIDGE-BELL

Labouchere Hillyer Bainbridge-Bell, M.C., M.A., who died on the 7th August 1956, was born on the 17th August 1893. He was educated at Marlborough and Emmanuel College, Cambridge, taking the Mathematical Tripos Part I in 1913. He was granted a B.A. degree in engineering in 1916, while on active service.

During the 1914–18 War he served in the Signals branch of the Royal Engineers and was awarded the Military Cross after the battle of the Somme. Later he saw service in Egypt as a wireless officer in the R.A.F.

During the inter-war years he spent six years in the Research Department of the Radio Communication Co. and then in 1927 he went to the Radio Research Station, Slough, first working on atmospheric direction-finding and subsequently developing apparatus for use in ionospheric observations. In 1936 he joined the Air Ministry scientific staff for work on radar, and for his part in this development he received, in 1951, an award of £2400 from the Royal Commission on Awards to Inventors. It was characteristic of Bainbridge-Bell that he immediately gave the money to charity.

In the first week of the 1939–45 War he was transferred to H.M. Signal School at Portsmouth for work on radar, and when the German warship *Graf Spee* was scuttled off the River Plate, he flew out to Montevideo, where he confirmed that the enemy was using shipborne radar. In 1942 he moved to the newly-established Admiralty radar development laboratories at Witley. Here his interest in the presentation of technical information developed to such an extent that it became a full-time job, and he was eventually charged with responsibility for all technical information services at the Admiralty Signal and Radar Establishment. For several years he personally edited all technical notes and reports produced there.

His work was conducted with missionary zeal and naturally attracted many extra-mural duties as adviser to associated committees and protagonist of the exact expression and clear delineation of description in the electrotechnical world. In 1948 he became a founder member of the Presentation of Technical Information Discussion Group, formed at University College, London. He also figured prominently at meetings of the British Standards Institution and related Service committees, where the task of rationalizing the vast wartime accumulation of electronic language was being tackled.

In the summer of 1953 Bainbridge-Bell retired from the Admiralty service, but this only served to release more energy for his work on glossaries and symbols. He was immediately employed as secretary to various committees of the B.S.I., and in this capacity continued to provide his former associates with the benefit of his unrivalled knowledge of electrical definitions and symbols and the boundless enthusiasm with which he attacked the most mountainous labours.

His work was his chosen interest and absorbed so much of his time that there was little left for anything else. But a colourful personality like Bainbridge-Bell could hardly exist without diversion into the by-ways of contemporary life; and conversation with him soon revealed odd pieces of knowledge, culled from his searchings into these by-ways.

He was a churchman by heredity and conviction; a man of charity and generosity, ever ready to contribute to a good cause or to help a needy person. He was a country lover, an inquirer into local history and an active worker for the local museum. He had interests in the National Film Society, and enjoyed attendance at the cinema although he was not much of a theatre-goer. Motor cars, aeroplanes, clocks and mechanical devices of all sorts came within range of his curiosity, and he could speak with authority on these and many kindred subjects. Above all he was a talker, prominent in the company of men of his own profession, always speaking from a well-stored mind and heard with the respect due to scholarship and integrity.

Mr. Bainbridge-Bell joined The Institution as an Associate Member in 1925 and was elected a Member in 1947. R. H. G.

GEORGE MAURICE WRIGHT

George Maurice Wright, C.B.E., B.ENG., who died on 26th August 1956, was born on the 18th September 1890. He was educated at Chesterfield Grammar School and at Sheffield University, where he took his B.Eng. degree. He obtained practical experience, during the university holidays, at B. Donkin and Co., Chesterfield. He joined Marconi's Wireless Telegraph Co. in 1912, when he became one of the team of pioneer workers under the direction of Mr. C. S. Franklin and Capt. H. J. Round. He assisted Capt. Round in the development of the Bellini–Tosi system of direction finding and quickly gave evidence of his outstanding technical ability. His work on direction-finding and on radio interception made him an obvious choice for a temporary commission in the R.N.V.R. soon after the outbreak of war in 1914. The work of Round, Wright and other members of the team in plotting the movements of the German naval forces and Zeppelin fleet was of great importance.

He rejoined the Research Department of the Marconi Company in 1919 and continued his work on the development of direction-finding. In this year he produced the aperiodic aerial system which made possible important improvements in accuracy and operational reliability.

In 1925 he was appointed Chief of the Research Department, and for several years gave his attention to the development, among other things, of facsimile telegraphy. Many new techniques were developed, including a patent, dated 1925, which included frequency modulation and the use of limiters. The facsimile system was tested on the North-Atlantic route, between Rocky Point and Summerton, during the early days of the short-wave beam system. These transmissions brought to light many phenomena associated with short-wave propagation which were investigated by another member of the Research Department staff, Mr. T. L. Eckersley. From these observations Eckersley developed his theories of the scattering of short waves.

Mr. Wright was appointed a member of the Radio Research Board of the Department of Scientific and Industrial Research. He was in fact the first member from the radio industry so to serve.

He left the Marconi Company in 1938 to join the Admiralty, and later became Assistant Director of Scientific Research.

During the latter part of the war he was appointed Chief Scientist to the Admiralty Signal and Radar Establishment.

He rejoined the Marconi Company in 1946 as Engineer-in-Chief, which position he held until his retirement in 1954. Until shortly before his death he was a technical consultant to the company.

In recognition of his valuable contribution to radio research, he was invited to rejoin the Radio Research Board in 1948. He was appointed a C.B.E. in 1950.

'G. M.', as he was known to a wide circle of friends in the Government scientific services and industry, was a distinguished figure, and his courteous manner and quiet persistence with which he pressed home his arguments will be remembered with affection by all who knew him. Many of the younger members of his staff will remember his sympathetic approach to their problems, and his kindly and thoughtful advice.

Mr. Wright, and his wife Dorothy and their three children, who survive him, had a very happy family life. He had a wide range of interests, both in science and the arts, which was fully shared by his family. It is gratifying to know that his sons Peter and Paul follow their father's profession and are in the Government scientific services, while his daughter Elizabeth is the wife of Mr. R. W. Sutton, the Superintendent of the Services Electronics Research Laboratory (Admiralty).

Mr. Wright joined The Institution as a Member in 1946. He served on the Radio Section Committee from 1946 to 1949.

B. N. McL.

Wiring Regulations—Recent Interpretations

(Issued on the 3rd December 1956)

The 13th Edition of the Regulations for the Electrical Equipment of Buildings was issued on the 1st September 1955, and the first group of abstracts of interpretations of regulations in the 13th Edition was issued on the 3rd September 1956 to the technical Press at home and oversea; these were published in the *Journal*, October 1956, page 598. Separate reprints are available from the Secretary, price 1s. 3d. each, post free.

The following abstracts of interpretations, the second group concerning the 13th Edition to be published, are of general interest and involve clear-cut issues. As is customary the names of inquirers are not included. In some instances the inquiries and replies have been edited to make the interpretations of more general application. In view of the interest widely expressed, arrangements have been made to release further abstracts of this kind at regular, probably quarterly, intervals.

It should be borne in mind that The Institution cannot undertake to comment on particular installations or types of equipment and material. Such a duty falls within the province of a professional consulting electrical engineer or a testing establishment. Nor does The Institution attempt to adjudicate on differences of opinion which may arise between supply undertakings and consumers; the statutory provisions for dealing with such matters in Great Britain are contained in the Electricity Supply Regulations, 1937* (H.M. Stationery Office), and in Northern Ireland in the Regulations of the Ministry of Commerce.

Inquiry 23 *Regulation* **114(B)(ii)**

I find that it is difficult, if not impossible, to connect 7/·029-inch cable into the clock connectors normally available on the market.

Can Regulation 114(B)(ii) be relaxed to permit short lengths, e.g. 6ft, of spur running solely to clock connectors, to be of reduced cross-sectional area, e.g. 3/·029 inch?

Reply

It is understood that clock connectors in which 7/·029-inch cable can be accommodated are available, including a type specifically designed for use with ring circuits.

Regulation 114(B)(ii) admits of no exemption to the requirement that 7/·029-inch cable must be used throughout in ring circuits.

It is, however, admissible to terminate a spur of 7/·029-inch cable in a spur box from which a cable having smaller conductors may be run to the clock connector, provided it is protected in accordance with Regulation 108 by the fuse in the spur box.

Inquiry 24 *Regulations* **214(B)** *and* **404**

1. If, in accordance with the exemption to Regulation 214(B), bonding at points of contact is carried out where, say, conduit actually touches gas or other metal pipes, is Regulation 404 *automatically* invoked so that all baths, exposed metal pipes, sinks, etc., must be bonded and earthed:

(*a*) irrespective of where the bonding is located,
or (*b*) only if the bonding is in the same room as the bath, exposed metal pipes, etc.?

2. Assuming no other connection between the wiring and the metalwork of any other system, is there still segregation (so that earthing and bonding of bath, sink, etc., are unnecessary) if one of the following circumstances applies:

(*a*) the main earthing-lead is connected to the main cold-water feed;
(*b*) an immersion heater is installed;
(*c*) a self-contained electric water-heater is installed;
or (*d*) a gas/electric washing machine is installed?

* By virtue of Section 60 of the Electricity Act, 1947, and Section 1 of the Electricity Re-organization (Scotland) Act, 1954, these Regulations made by the Electricity Commission now have effect as if made by the Minister of Fuel and Power and the Secretary of State for Scotland acting jointly under these Acts.

Reply

1. Regulations 214(B) and 404 require bonding of pipes, etc., of other services to the earth-continuity conductor at positions where segregation of the earth-continuity conductor from it is impracticable. The Regulations do not call for such bonding elsewhere.

2(*a*) The connection of the earthing-lead of an installation to a metal water-pipe system in accordance with Regulation 409(C) would not preclude segregation of the earth-continuity conductor in the remainder of the installation, in accordance with Regulation 214(B).

(*b*) The means of jointing an immersion heater to a water tank cannot generally be relied on to afford either effective segregation or effective bonding; bonding by means of a separate conductor would thus normally be required (cf. CP 324.202 'Domestic electric water-heating installations', Clause 503).

(*c*) Connection to the earth-continuity conductor of the earth terminal of an electric water-heater complying with B.S. 843 would normally satisfy the requirements.

(*d*) Where a gas/electric washing machine is installed, much depends upon the design of the machine and on the arrangement of connections to the gas and water services. If means of effective segregation are not available, effective bonding, using a separate conductor where necessary, would be required. Further consideration is being given by the appropriate bodies to the design of combined gas/electric appliances.

The foregoing does not refer to installations where the use of protective multiple earthing (P.M.E.) has been authorized; such installations must satisfy conditions imposed by the Minister of Fuel and Power.

Inquiry 25 *Regulation* **322**

It appears from Regulations 320 and 322 that both a neutral conductor of rating not less than that of the largest phase conductor and an earthing-lead having a similar rating must be connected to the shell of a 3-phase medium-voltage boiler, together with the sheath and armour of the cable. Thus under fault conditions there would be three earth paths. Is this reading of the Regulations correct?

Reply

When a 3-phase medium- or low-voltage electrode boiler is installed in accordance with Regulation 322, the connection of the shell of the boiler 'to the neutral of the supply as well as to the earthing-lead' may be accomplished by a single conductor between the earthing terminal of the boiler and the associated switchboard, where it must be connected both to the neutral of the incoming cable and to the consumer's earthing-lead.

This conductor should be of the same cross-sectional area as the phase conductors (see Regulation 407), and the cable sheath and armour (if any) should be bonded in parallel to it, for the sheath and armour are unlikely to have sufficient conductance to serve adequately alone.

Inquiry 26 *Regulation* **403**

Is a flush-pattern switch mounted on a plaster-depth metal box exempt from the requirement of earthing by reason of Exemption (v) to Regulation 403?

In some installations, although the plate-fixing screws are slightly recessed, it would be quite easy to touch these screws with a metal object. Should a fault develop and the box were not efficiently earthed, they could become live, a condition which might prove dangerous.

Reply

The question of earthing a plaster-depth switch-box is not one which can be decided without full knowledge of the conditions and situation of the type of switch to be used. The planner of the installation must thus consider whether or not a particular switch complies with Regulation 403, Exemption (v), in respect of being screened by non-conducting material.

The question is receiving further study, with a view to its treatment in a future edition of the Regulations.

Inquiry 27 *Regulation* **405**(D)

When immersion heaters are installed in bathrooms, 3/·036-inch twin-core cable with 1/·044-inch earth-continuity conductor is used for the main wiring run and 70/·0076-inch heat-resisting flexible cord for the connection to the heater.

Regulation 405(D) requires that in a room containing a fixed bath the earth-continuity conductor shall be of tinned copper wire not smaller than 7/·036 inch or its equivalent. It would be possible to meet this requirement by terminating the normal wiring run outside the bathroom and using twin-core cable and flexible cord together with a separate 7/·036-inch earth wire inside the bathroom. This appears unsatisfactory because that part of the earthing circuit outside the bathroom would consist of the 1/·044-inch conductor in the composite cable, and moreover there would be an additional joint in the earth-continuity conductor.

On the other hand, does Regulation 405(D) apply only to a separate earth-continuity conductor installed in accordance with Regulation 404(i)? In this event earthing by a composite cable having an earth-continuity conductor complying with Table 5 and a flexible cord with earth-continuity conductor would be acceptable.

Reply

The requirement of Regulation 405(D) that the earth-continuity conductor in a room containing a fixed bath should be not smaller than 7/·036 inch or the equivalent, applies to an earth-continuity conductor which is within a bathroom and does not form part of a composite cable (which itself provides a measure of mechanical protection).

The Regulations do not require an earth-continuity conductor of this size to extend to the consumer's earth terminal; the earth-continuity conductor used for this connection is required to comply with Regulation 407(B), which refers to Table 4 or 5, as applicable. If a water-pipe forms part of the earth-continuity conductor, the requirements of Regulation 407(B)(v) must be observed.

In regard to risk of corrosion when reliance is placed, for example, on a 1/·044-inch conductor in a composite cable for earthing an appliance in a bathroom, attention is drawn to the requirements for periodical inspection and testing (Regulation 511).

The foregoing does not refer to installations where the use of protective multiple earthing (P.M.E.) has been authorized; such installations must satisfy conditions imposed by the Minister of Fuel and Power.

IDEAL ACTIVE ELEMENTS

From G. E. SHARPE, B.SC.(ENG.), ASSOCIATE MEMBER

It is generally believed at the present time, that every linear active network can be synthesized by means of six basic types of elements, namely:

(i) The five passive elements: resistance, inductance, capacitance, ideal *gyrator* and ideal transformer.

(ii) The one active element: negative resistance.[1,2]

The *gyrator* (Fig. 1) is a new, lossless, 4-terminal circuit element, recently introduced by Tellegen.[3] It has non-reciprocal coupling properties. It may be defined by its open-circuit impedance matrix:

$$Z = \begin{bmatrix} 0 & -r \\ r & 0 \end{bmatrix} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where

$$v_1 = -ri_2$$
$$v_2 = ri_1$$

and r is called the *gyration resistance*.

There is, however, an alternative approach to the problem, based on the postulation of a group of ideal active elements, which does not seem to have been previously considered.

A sketch of the method will now be given.

Definitions

(*a*) A terminal pair is called *sensitive* if it responds to an impressed voltage, or current, or to both. Otherwise it is *insensitive*.

(*b*) A *control* terminal pair is a sensitive terminal pair.

(*c*) An *activity* terminal pair is an insensitive terminal pair from which useful output may be obtained.

(*d*) An element is *active-definite* if the quadratic form of its terminal power relationship is negative-definite.

An ideal active element must obey the following laws:

1 *Control and Power*

It must possess at least one control and one activity terminal pair.

2 *Separation*

It must have its control and activity terminal pairs separated to avoid feedback.

3 *Stability*

It must be intrinsically stable.

4 *Activity*

It must consist only of parts which contribute to its activity, and these parts must be active-definite.

A mathematical interpretation of these laws leads to the postulate of two new active elements. These are 4-terminal and unilateral, and they have been given the name *ideal transactors*. A voltage-current transactor (v.c.t.) is defined by its admittance matrix:

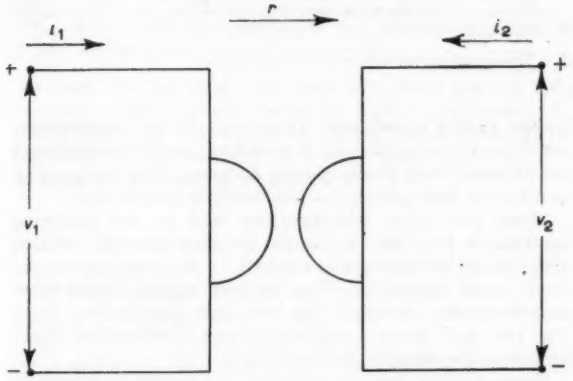
$$Y = \begin{bmatrix} 0 & 0 \\ y & 0 \end{bmatrix} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

A current-voltage transactor (c.v.t.) is defined by its impedance matrix:

$$Z = \begin{bmatrix} 0 & 0 \\ z & 0 \end{bmatrix} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where y and z may be complex. Both elements are shown in

Mr. Sharpe is with British Telecommunications Research, Ltd. *His letter was received on the 1st November, 1956.*



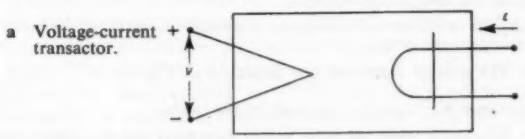
1 *The ideal gyrator*

Fig. 2. The case for real y and z will now be considered. The causal equations for these elements are:

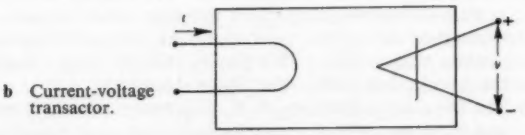
$$\text{[V.C.T.]} \quad y.v \rightarrow i$$
$$\text{[C.V.T.]} \quad z.i \rightarrow v \quad . \quad . \quad . \quad . \quad (4)$$

where the arrow implies that the process is not reversible. These active elements are physically quite distinct, and their method of operation is characterized by an irreversible electric to magnetic (or magnetic to electric) transfer action. They have therefore been called the *transactor elements*.

In these elements, complete separation of voltage and



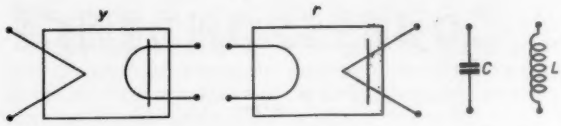
2 *The ideal transactors*



current branches is obtained, and consequently a current branch is denoted by the letter C (or C turned through 180°), and a voltage branch by the letter V laid on its side (or turned through 180°). The bar across a branch indicates that transmission is unilateral from the closed to the open end of the branch. This notation is simple and has been successfully used by the author for a long time.

Now, it may be shown that a 2-terminal negative resistance cannot be active and stable. Moreover, it does not exhibit the essential physical distinction that is intrinsic to active elements (see equations 4). It may therefore be better replaced by the transactor elements.

When two v.c.t.'s (or c.v.t.'s) are suitably connected in parallel (or series) a gyrator is obtained. Two gyrators in



3 *The ideal active and passive elements*

tandem yield a transformer. These gyrators and transformers are, however, active-derived. It is well known that transformers can be made from purely passive materials. It is not quite so well known that gyrators can be similarly constructed.[4]

These and other considerations lead to the following equivalence principle: a lossless coupling network realized with the aid of ideal active elements is physically equivalent to the same lossless coupling network realized solely from passive-coupled elements. The view may therefore be taken that the ideal gyrator and transformer represent an idling lossless active-element configuration.

When a v.c.t. (or a c.v.t.) has its control and activity branches suitably connected in parallel (or in series) an admittor (or a resistor) is obtained. The resistor (or admittor) is, however, active derived. In an analogous manner, one may come to the conclusion that a resistor (or an admittor) represents the degenerate working of an ideal active element and thus forms a dissipative subgroup of the transactor elements.

A very interesting fact now emerges: the dissipation of energy by means of resistance is known to represent an irreversible process. The use of transactors clearly shows that it may be of one of two distinct physical kinds, namely electric to magnetic, or magnetic to electric.

Before the results obtained are summarized the following definitions are given:

(i) The two 4-terminal ideal active elements c.v.t. and v.c.t. will be called the ideal active elements.

(ii) The two 2-terminal ideal passive elements *L* and *C* will be called the ideal passive elements.

These four elements are depicted in Fig. 3.

Summary of results obtained by the author

1 Negative resistance is better replaced by the ideal active elements.
2 The gyrator and transformer may be considered to form a lossless idling configuration of the ideal active elements.
3 Resistance and conductance represent a physically distinct process of dissipation. This may be derived from a degenerate connection of the ideal active elements.
4 The five passive elements, *R*, *L*, *C*, gyrator and transformer, and the active element, negative resistance, may be replaced by the ideal passive elements, and the ideal active elements and their derivatives.
5 The ideal elements and their derivatives are necessary and sufficient to synthesize all networks, whatever their degree of complexity.

Details of the research on which the results are based will be published elsewhere.

1 BELEVITCH, V.: 'Fundamental Results and Outstanding Problems of Network Synthesis', *Tijdschrift van het Nederlands Radio-Genootschap*, **18**, 1953, p. 33.
2 CARLIN, H. J.: 'On the Physical Realizability of Linear Non-Reciprocal Networks', *Proceedings of the Institute of Radio Engineers*, 1955, p. 615.
3 TELLEGEN, B. D. H.: 'The Gyrator, a New Electric Network Element', *Philips Research Reports*, 3, 1948, p. 81.
4 British Patent No. 716257.

MACHINE TRANSLATION

From DENIS WILLIAMS, ASSOCIATE MEMBER

The paper on machine translation reviewed on page 677 of the November *Journal* purports to give an example of the results of such a translation by presenting the Russian translation of an article from *The Times*.

May I draw attention to a few puzzling points from this translation?

It would of course be possible to establish the idiom from a word-for-word translation of such idiomatic phrases as 'at any rate' (*English, line 2*), 'in every case' (*Russian, line 2*) by a check back for two or three words, but 'orator' (*R., l. 6*) is not the equivalent of 'speaker' (*E., l. 6*) unless the meaning of the rest of the sentence is understood; on the other hand the machine should have no difficulty in translating 'Iron Curtain', although the meaning of this might escape a Russian not familiar with western newspaper gossip.

The meaning of the full sentence is again necessary to the use of 'collaboration' (*R., l. 15*) for 'in conjunction with' (*E., l. 17*) whilst the use of 'visual or graphic' (*R., l. 17*) for 'popular' (*E., l. 19*) implies an unbelievably fine distinction between 'popularize', which has been borrowed into Russian as it is, and 'present in a manner understandable to the lay mind'.

One is driven to the conclusion that the Russian text is not the product of the machine but has been worked up afterwards by something more human. This is emphasized by the odd 'containing' (*R., l. 5*) in place of 'for that matter' (*E., l. 5*), in which both idiomatic and literal meanings have been put on one side, and 'had in view' (*R., l. 6*) for 'had a version . . . done' (*E., ll. 7 and 8*) which bears no resemblance to the original, either literal or otherwise, although it would not be impossible in a free translation.

The text of machine translation would surely to a very large extent be incomprehensible to the layman; and even to the expert linguist, as the above indicates, reading or working over from the literal to the idiomatic must need considerable practice.

APPEARANCE DESIGN

From O. D. ROBINSON, MEMBER

I am writing to comment on Sir Gordon Russell's address given after the Annual General Meeting of The Institution last year, which was reported in the October 1956 issue of the *Journal*. There are no doubt many members who register profound disagreement with certain of Sir Gordon's statements and feel, with me, that they ought not to go unchallenged.

I challenge then, to begin with, the right of Sir Gordon (and all his Council) to be dogmatic about what looks nice. Beauty is still in the eye of the beholder, and its effect on the individual is such a highly personal thing that it is surely impossible to lay down any rules or standards. Does not therefore all the Council can say about any particular design consist entirely of *their own reactions* to it? This being so, is not Sir Gordon's wish that every engineer should have some kind of aesthetic training saying in effect: 'Certain forms of design or beauty appeal to me. I should like all engineers therefore to be trained to accept these as standard so that anything they produce will be of a shape that appeals to me and will therefore be a good design.'

Now we come to the unfortunate state of affairs outlined by Sir Gordon in which generally (generally, mark you!) engineering students are brought up in industrial towns amongst buildings which are largely not of pleasing design, and, surrounded by these ugly buildings, they will, *ipso facto*, make ugly machines. Could any theory be more fantastic? Do these poor shut-in engineers never leave their squalid home towns! Of course they do. They visit other towns; they go to the sea and the country. They see the patterns of nature and the villages, the bridges, the castles and other buildings. They are more likely to be influenced in their designs by these things than by the allegedly drab surroundings of their home towns.

Sir Gordon said, in connection with locomotive design, that original thinking was nearly always good. But not apparently the original thinking of the engineer of to-day, who, it seems, needs someone to tell him what he ought to think looks nice.

How lucky were those early nineteenth-century locomotive engineers to live amongst all that architectural excellence. It must have had a great influence in the design of those queer, long-funnelled jobs to be seen in the Science Museum.

Sir Gordon comments on 'the awful thing that happens to so many of our power stations'. I think his remarks are a rather cheap sneer at the architects. Most of them have produced structures of quite pleasing appearance in spite of the difficulties of combining tall chimneys, squat horizontal turbines and generators, big fat boilers, coal hoppers, condensers and all the other odds and ends, into a harmonious whole. The fact that Sir Gordon does not want to see bricks put upright does not make it sinful to do it. Many people may like them that way. The same applies to the yellow generators. The personal preference of a colourist for a certain colour scheme in no sense confers on that particular combination any special quality of 'rightness'; the engineers no doubt rejected yellow generators because they just thought blue ones looked nicer. The appeal of line, colour, grouping and mass is so much a question of personal taste, that I venture to append my own opinions of the six examples depicted—and some comments on Sir Gordon's opinions.

1 I cannot see why we should be particularly proud of this. To me the train seems a rather dreary succession of plain little boxes on wheels. On Sir Gordon's theory the designer, I think, must have spent his early formative years on a council estate.

2 I agree this design is attractive, but surely it would not 'look well in almost any room'. I certainly should not like it in my lounge or my bedroom. I have not measured it but it seems to me to be nearly all 'golden section' or a close approximation to it, and its pleasing appearance lends support to the classical claim for these proportions.

3 I think, too, the appearance of this heater is reasonably agreeable. The fact that it gapes at you like a large open mouth cannot be avoided because the reflector must be that shape to do its job. But the base seems to be rather dangerously small, and the aluminium reflector is not a good feature, for aluminium loses its lustre fairly quickly and is not easily restored.

4 I do not like plastics very much (and I am quite *entitled* not to), but many of course do and will buy this set because it is reasonably good-looking. Its performance will be acceptable, despite the possible absence of many frequencies below middle C.

5 Why 'aberration'? What is wrong with brick and half-timbering? The design is cosy and it has the authentic tavern atmosphere. The possible disadvantage of the tables having seats on one side is balanced by the advantages of the intimacy of side-by-side conversation. The inability to look out of the windows is not all that important. The view is often lacking in appeal; you may have seen it on both sides so many times you hate the sight of it; it may be dark, foggy or raining, or the windows may be too steamed up to see through. Altogether I think the words 'it was an extraordinary example of how not to do something' are a somewhat arrogant condemnation of a design which would be regarded by many as entirely satisfactory.

6 I am glad Sir Gordon does not want the Tower Bridge removed. Neither do I. I think it is thoroughly lovely and that its loveliness is helped by the very incongruity which is alleged to have surprised the tower in the background. To me many of our old towns owe their delightful appearance to this same feature. The throwing together in a haphazard mass of all the different styles and periods has produced a charm and attractiveness entirely absent from many of the geometrical horrors designed by the modern town planners.

Finally, let me stress the point that these are my own opinions. I claim no omniscience for them as some appear to do for theirs, but I do claim that on this kind of subject their eligibility for consideration is exactly equal to those of a professional aesthete, or of anyone else.

'CHARTERED'

From B. J. DAVIS

Your article in November under the above heading is of great interest, and I am glad that the Chartered Electrical Engineers are concentrating on making the title well known.

Although the expression 'Chartered Accountant' is now well known almost everywhere, it must be remembered that it dates back to 1880. Who first thought of this title I do not know, but it is interesting to observe that in the preamble to the Royal Charter of the Institute of Chartered Accountants in England and Wales, granted in 1880, the petitioners for the Charter humbly pray for the incorporation under the title of the 'Incorporated Institute of Accountants in England and Wales or under such other title as to Us might seem fit . . .'. It is evident that when the petition for the Royal Charter was made no one had thought of this new title, but before the Royal Charter was actually granted some genius must have hit on it, because, in the incorporation clause, the body is incorporated with its present name.

The first body of accountants in Scotland was the Society of Accountants in Edinburgh, incorporated by Royal Charter in 1854. The Institute of Accountants and Actuaries in Glasgow was incorporated in 1855, and the Society of Accountants in Aberdeen was incorporated in 1867. So far as I am aware none of these three bodies incorporated by Royal Charter provided its members with the right of describing themselves as Chartered Accountants, but somehow, as time went on, the members did in fact describe themselves in this way, and adopted the abbreviation 'C.A.' In fact, however, the right to the title of Chartered Accountant and to the initials 'C.A.' was not granted until a few years ago, when the three bodies were amalgamated in the Society of Accountants in Edinburgh, which changed its name to the Institute of Chartered Accountants of Scotland. In the supplemental Charter then granted the members had the right to describe themselves as Chartered Accountants and to use the initials 'C.A.' as an abbreviation. Whether the Scottish accountants adopted the title of Chartered Accountant before it was adopted in England, I do not know. Now, however, the members of the Scottish Institute have exclusive right to the initials C.A.; in England, of course, these initials stand for 'County Alderman'. The members of the English Institute use the initials 'F.C.A.' and 'A.C.A.' to denote Fellows and Associates.

Now that there are so many associations not formed by Royal Charter it is in my opinion a matter of great importance for the Chartered bodies to stress the fact that they originate, by means of a Royal Charter, from the Crown.

MONOGRAPHS AND PAPERS
published individually this month

Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of 8 vouchers may be obtained from the Secretary, price 10s. each.

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MONOGRAPHS

A New Theorem in Electrostatics with Applications to Calculable Standards of Capacitance

MONOGRAPH No. 216 M

D. G. LAMPARD, M.Sc., Ph.D.

The monograph presents what is believed to be a new theorem in electrostatics, showing that the direct capacitance of a very general type of cylindrical 3-terminal capacitor is a constant, namely $(\log_e 2)/4\pi^2$.

The presentation and proof of this theorem are followed by a detailed analysis of a cylindrical 3-terminal capacitor of rectangular cross-section, in which the effects of various practical limitations are evaluated in quantitative terms. The results of similar analyses of cylindrical 3-terminal capacitors of other cross-sections are stated.

As a consequence of this work, it appears that such cylindrical 3-terminal capacitors are extremely attractive as precise calculable standards of capacitance, only one precision length measurement being necessary to enable their capacitance to be computed to a high order with great accuracy.

Torque-Angle Analysis of the Schrage Motor

MONOGRAPH No. 217 U

N. KESAVAMURTHY, M.A., M.Sc.(Tech.), and R. E. BEDFORD, B.Sc., Ph.D.

Reliable equations of performance for the Schrage motor are deduced in terms of the angle between the stator and the rotor magnetomotive force waves, resulting in an original treatment. The expressions for torque, slip and currents in terms of this angle are derived and are discussed with the aid of graphs and locus diagrams.

Properties of Some D.C.–A.C. Chopper Circuits

MONOGRAPH No. 218 R

I. C. HUTCHEON, M.A.

The monograph analyses five basic types of chopper circuit suitable for converting low-level direct voltages to alternating voltages. Three of them are capacitance coupled and two are transformer coupled; all have resistive loads.

Both transformer-coupled circuits have make-before-break (overlap) contact action and incorporate a stopper resistor. If the overlap is small, this arrangement provides input resistances which approach those of the equivalent buffered underlap circuits, together with several other advantages.

Expressions are derived for gain, input resistance and optimum stopper resistance in terms of the component values.

The Measurement and Prediction of Induction Motor Stray Loss at Large Slips

MONOGRAPH No. 219 U

T. H. BARTON, Ph.D., and V. AHMAD, M.Sc.

It is shown that the stray loss in induction motors, at fractional slips greater than about 0·25, is almost entirely due to tooth ripple in the zigzag leakage flux. The stray loss is large; it can double the torque at a slip of 2·0 and can lead to serious errors when calculating accelerating and braking performance. In the normal operating range, i.e. slip less than 0·05, although the stray loss is much lower it is still appreciable, and the component associated with tooth ripple in the main flux is of importance. Experimental evidence, both from actual machines and from high-frequency loss in samples of laminations, indicates that the zigzag leakage flux component of the loss is approximately proportional to $(\text{speed})^{1\cdot6}$ and $(\text{current})^{1\cdot9}$, and the results of the American Standard reverse-rotation test extrapolated according to this law are sufficient, together with the no-load stray loss, to predict the total stray loss over the whole practicable speed range.

A simple method for calculating the stray loss is given and its limitations are indicated. Calculated values of the loss are compared with the measured losses, but no definite conclusions as to the accuracy of the calculations can be drawn until more is known of the high-frequency loss in machine laminations.

PAPERS

Junction-Transistor Bootstrap Linear Sweep Circuits

PAPER No. 2228 R; PART B

K. P. P. NAMBIAR, B.Sc., and A. R. BOOTHROYD, B.Sc.(Eng.), Ph.D.

The authors describe junction-transistor linear-sweep circuits of the 'bootstrap' type for which deviations from perfect sweep linearity of much less than 1% are estimated to be possible. The operation of the circuits depends on the properties of the emitter-follower amplifier stage; these properties are shown to be very well suited for such applications. The basic bootstrap circuit is closely related to its thermionic-valve counterpart and is very versatile, being readily arranged in externally gated, monostable or astable forms; a variety of

useful waveforms such as rectangles or delayed pulses may be generated, in addition to the linear voltage sweep. One form of monostable circuit described is particularly precise in operation, the timing duration being defined by the comparison of an accurate linear-voltage-sweep waveform with a reference potential by means of a transistor blocking-oscillator comparator.

The limitations imposed on the circuits by the frequency-dependent properties of the transistors are investigated, and it is shown that these result in initial transients at the beginning of the sweep involving time-constants of the order $1/\omega_\alpha$; furthermore, the transients concerned are not serious. Finally, quite fast, yet accurate, linear sweeps are shown to be possible, examples being given of circuits generating sweeps of less than 1 microsec duration.

To be read on the 23rd January.

Development of Transportable Thermal-Storage Space Heaters

PAPER No. 2284 U; PART A

E. BATES

Reference is made to the shortage of generation, transmission and distribution capacity after the end of the 1939–45 War and upon the resumption nationally of normal activities. This prompted a renewal of interest in the storage of energy in the form of heat, and the paper describes briefly experiments that were made leading up to the design and production in this country on a commercial basis of transportable unit-type thermal-storage space-heaters. The suitability of buildings for this form of heating is discussed, as also are methods of planning and controlling installations. In forecasting the future of this form of heating there is reference to electricity tariffs and to the relative costs of electricity and other forms of fuel.

Due for reading in the second half of the Session.

Minority-Carrier Storage in Semi-Conductor Diodes

PAPER No. 2293; PART B

J. C. HENDERSON, B.Sc., and J. R. TILLMAN, D.Sc., Ph.D.

Hole storage is an effect which takes place in semi-conductor valves using *n*-type base material; it has a counterpart in electron storage in *p*-type material. It gives rise to several electrical effects, particularly to transient reverse currents in diodes on application of a reverse bias. The effects are deduced, quantitatively, by solving the continuity equation with boundary conditions appropriate to the geometry and the external circuit. Planar and hemispherical diodes are analysed separately, although the first is only a special case of the second. Parts of the analyses assume a reverse voltage to be applied immediately after the passage of forward current; another part assumes delay and calculates the decay of floating potential which results. Both significant and negligible limiting of the transient reverse current, by the external circuit, are considered. The analyses are tested by experiments and used to deduce the hole lifetime in the base material of experimental diodes. Fair agreement is recorded between methods based on measurements of (*a*) the decay of current at short and at long times after the application of reverse bias, (*b*) the duration of limiting potential, and (*c*) the decay of floating potential.

To be read on the 23rd January.

Design Considerations for Junction-Transistor Oscillators for the Conversion of Power from Direct to Alternating Current

PAPER No. 2299 R; PART B

F. OAKES

Resonant oscillators using transistors provide a suitable means for the conversion of d.c. to a.c. power, in particular where reasonably sinusoidal output voltage is required.

For the design of such oscillators, feedback and transistor operating conditions have to be considered, and a criterion for maintenance of oscillation is derived in the form of a maintenance equation. An angle-of-flow chart is described, by means of which sets of values of the amplitude of oscillation, the current amplification of the transistor, the amount of feedback and the fraction of the cycle during which collector current is flowing can be readily determined, so that the maintenance equation is satisfied. Practical oscillator design has to take into account the non-linearity of the transistor circuit which has to be incurred in order to ensure correct amplitude limiting of the oscillator. Deviations resulting from this as well as from other causes are considered in some detail, and graphical methods are described for the assessment of oscillator performance. These methods provide a convenient means of predicting the amplitude, output waveform, frequency and other performance data of the oscillator.

The design of a Class B oscillator is described in detail and illustrated by means of a numerical example. Calculated data agree well with practical measurements.

To be read on the 23rd January.

The Ultimate Performance of the Single-Trace High-Speed Oscillograph

PAPER No. 2306 M; PART B

M. E. HAINE, M.Sc., and M. W. JERVIS, M.Sc.Tech.

The limitations on writing speed and deflection sensitivity of the single-trace high-speed oscillograph are analysed in terms of theoretical electron-gun performance and the spherical aberration of practical electron lenses. It is shown that considerable improvements over the best present-day designs are theoretically possible. The results indicate the design trends which should achieve the improved performance.

To be read on the 12th February

The Design and Performance of a New Experimental Single-Transient Oscillograph with Very High Writing Speed

PAPER No. 2307 M; PART B

M. E. HAINE, M.Sc., and M. W. JERVIS, M.Sc.Tech.

The paper describes the design and construction of a new high-speed cathode-ray oscillograph for recording single transients. A demountable construction is used, which enables various types of deflector system to be employed and allows the current in the final spot to be measured by a Faraday cage moved to intercept the beam. Recording is by the direct action of electrons on a photographic plate.

The temporal resolution is measured from oscillograms of voltages of frequencies up to 9 080 Mc/s, the limiting resolution being 2×10^{-13} sec per spot width. This figure is in agreement with design predictions.

To be read on the 12th February.

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month that a synopsis has appeared in the *Journal* under 'Monographs and Papers published individually this month', i.e. about the time the paper has been published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. See page 36 for particulars of ordering individual papers.

January 1957

E **15** *Tuesday* H. E. DANCE, M.ENG., *and* P. F. SOPER, PH.D. (ENG.), B.SC.(ENG.), will open a discussion on 'Distribution of Power Supplies in Electrical Laboratories'* (At 6 p.m., tea at 5.30 p.m.)

U **16** *Wednesday* Section Dinner-Dance (at the Café Royal)

U **17** *Thursday* C. A. CAMERON BROWN, B.SC., *and* A. W. GRAY. 'Electricity in Modern Commercial Horticulture' (Paper No. 2272 U)

R **23** *Wednesday* K. P. P. NAMBIAR, B.SC., *and* A. R. BOOTHROYD, B.SC.(ENG.), PH.D. 'Junction-Transistor Bootstrap Linear-Sweep Circuits' (Paper No. 2228 R) *Synopsis:* See p. 36.

F. OAKES. 'Design Considerations for Junction-Transistor Oscillators for the Conversion of Power from Direct to Alternating Current' (Paper No. 2299 R) *Synopsis:* See p. 37

J. C. HENDERSON, B.SC., *and* J. R. TILLMAN, D.SC., PH.D. 'Minority-Carrier Storage in Semi-Conductor Diodes' (Paper No. 2293 R) *Synopsis:* See p. 37

O **24** *Thursday* **Symposium of papers on the Transatlantic Telephone Cable. (Joint Meeting, linked by the Cable, with The American Institute of Electrical Engineers and The Engineering Institute of Canada. At 6.45 p.m., tea at 6 p.m.)**

MERVIN J. KELLY, PH.D., D.ENG., D.SC., LL.D., *and* SIR GORDON RADLEY, K.C.B., C.B.E., PH.D.(ENG.). Foreword (Paper No. 2230) *Synopsis:* December 1956

E. T. MOTTRAM, R. J. HALSEY, J. W. EMLING *and* R. R. GRIFFITH 'Transatlantic Telephone Cable System—Planning and Objectives' (Paper No. 2274) *Synopsis:* December 1956

O **24** H. A. LEWIS, R. S. TUCKER, G. H. LOVELL *and* J. M. FRASER 'System Design for the North Atlantic Link' (Paper No. 2275) *Synopsis:* December 1956

T. F. GLEICHMANN, A. H. LINCE, M. C. WOOLEY *and* F. J. BRAGA 'Repeater Design for the North Atlantic Link' (Paper No. 2276) *Synopsis:* December 1956

H. A. LAMB *and* W. W. HEFFNER 'Repeater Production for the North Atlantic Link' (Paper No. 2277) *Synopsis:* December 1956

G. W. MESZAROS *and* H. H. SPENCER 'Power Feed Equipment for the North Atlantic Link' (Paper No. 2278) *Synopsis:* December 1956

J. O. MCNALLY, G. H. METSON, E. A. VEAZIE *and* M. F. HOLMES 'Electron Tubes for the Transatlantic Cable System' (Paper No. 2279) *Synopsis:* December 1956

A. W. LEBERT, H. B. FISCHER *and* M. C. BISKEBORN 'Cable Design and Manufacture for the Transatlantic Submarine Cable System' (Paper No. 2280) *Synopsis:* December 1956

R. J. HALSEY *and* J. F. BAMPTON 'System Design for the Newfoundland–Nova Scotia Link' (Paper No. 2243 R) *Synopsis:* December 1956

R. A. BROCKBANK, PH.D., B.SC.(ENG.), D. C. WALKER, B.SC.(ENG.), *and* V. G. WELSBY, PH.D., B.SC.(ENG.) 'Repeater Design for the Newfoundland–Nova Scotia Link' (Paper No. 2249 R) *Synopsis:* December 1956

J. F. P. THOMAS *and* R. KELLY 'Power-Feed System for the Newfoundland–Nova Scotia Link' (Paper No. 2251 R) *Synopsis:* December 1956

J. S. JACK, W. H. LEECH *and* H. A. LEWIS 'Route Selection and Cable Laying for Transatlantic Cable System' (Paper No. 2281) *Synopsis:* December 1956

M **29** *Tuesday* C. E. RICHARDS, E. V. WALKER, B.SC., *and* A. C. LYNCH, M.A., B.SC. 'An Experimental Study of High-Permeability Nickel–Iron Alloys' (Paper No. 2136 M) *Synopsis:* August 1956

A. C. LYNCH, M.A., B.SC. 'A Method for the Precise Measurement of Permittivity of Sheet Specimens' (Paper No. 2208 M) *Synopsis:* October 1956

A. C. LYNCH, M.A., B.SC. 'A Bridge Network for the Precise Measurement of Direct Capacitance' (Paper No. 2209 M) *Synopsis:* October 1956

W. F. LOVERING, M.SC., *and* D. B. BRITTEN, B.E. 'A Simple Transistor Bridge for the Measurement of Transistor Characteristics' (Paper No. 2247 M) *Synopsis:* December 1956

SM **30** *Wednesday* C. ADAMSON, M.SC.(ENG.), *and* L. M. WEDEPOHL, B.SC.(ENG.) 'Power System Protection, with particular reference to the Application of Junction Transistors to Distance Relays' [*Proceedings I.E.E.*, Paper No. 2085 S, August 1956 (103, Part A, p. 379)]

[*continued on p. 39*]

30 [contd.] C. ADAMSON, M.SC.(ENG.), *and* L. M. WEDEPOHL, B.SC.(ENG.) 'A Dual-Comparator Mho-Type Distance Relay Utilizing Transistors' [*Proceedings I.E.E.*, Paper No. 2177 S, September 1956 (103, Part A, p. 509)]

February 1957

R 4 *Monday* Informal evening on 'The Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering'. Talk by E. C. CHERRY, D.SC.

E 6 *Wednesday* E. H. HORROCKS, B.A., will open a discussion on 'The Place of Liberal Studies in Sandwich and Other Technological Courses'* (At 6 p.m., tea at 5.30 p.m.)

O 7 *Thursday* SIR IFOR EVANS, D.LIT. Third Graham Clark Lecture on 'The Place of Engineering in University Education'† (Joint meeting with The Institutions of Civil and of Mechanical Engineers)

MR 12 *Tuesday* M. E. HAINE, M.SC., *and* M. W. JERVIS, M.SC.TECH. 'The Ultimate Performance of the Single-Trace High-Speed Oscillograph' (Paper No. 2306 M)

M. E. HAINE, M.SC., *and* M. W. JERVIS, M.SC.TECH. 'The Design and Performance of a New Experimental Single-Transient Oscillograph with Very High Writing Speed' (Paper No. 2307 M) *Synopses:* See p. 37.

13 *Wednesday* T. E. ALLIBONE, D.SC., PH.D., F.R.S. The Faraday Lecture: 'Nuclear Energy in the Service of Man'‡ (At the Central Hall, Westminster, S.W.1, at 6 p.m. Admission by ticket obtainable from The Institution. A stamped addressed envelope should be sent with the application)

U 14 *Thursday* Three short papers

I 18 *Monday* DENIS TAYLOR, M.SC., PH.D., will open a discussion on 'The Impact of Radioactive Isotopes on the Utilization Field'*

R 20 *Wednesday* H. A. M. CLARK, B.SC., G. F. DUTTON, PH.D., *and* P. B. VANDERLYN 'The Stereosonic Recording and Reproducing System (Two-Channel System for Domestic Tape Records)' (Paper No. 2332 R) (Northampton Polytechnic)

25 *Monday* Discussion on the Report on Engineering Education in the Soviet Union. Copies of the Report can be obtained from The Institution. (Joint Meeting with The Institutions of Civil and of Mechanical Engineers at The Institution of Civil Engineers, Great George Street, S.W.1.)

M 26 *Tuesday* A. H. COOPER *and* D. A. DREW, B.SC., will open a discussion on 'The Analysis of Waveforms'†

S 27 *Wednesday* E. T. NORRIS 'Mechanical Strength of Power Transformers in Service' (Paper No. 2317 S)

28 *Thursday* Annual Dinner (At Grosvenor House, Park Lane, W.1, at 7 for 7.30 p.m.)

* No advance information will be available and no Press report will be permitted.
† An abstract of the introduction will be available in advance.
‡ No advance information will be available.

British Nuclear Energy Conference: Forthcoming Programme

FEBRUARY 15 *Friday*

A meeting sponsored by The Institution of Mechanical Engineers will be held at Church House, Westminster, at 6 p.m. (tea at 5.30 p.m.).

The Thomas Hawksley Lecture on SOME ENGINEERING PROBLEMS IN THE INDUSTRIAL DEVELOPMENT OF NUCLEAR ENERGY will be delivered by Sir Claude Gibb, K.B.E., D.SC., M.E., F.R.S.

Admission to this meeting will be by ticket only obtainable from the Secretary of The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1. Printed copies of the lecture will not be available until the close of the meeting.

FEBRUARY 21 *Thursday*

A meeting sponsored by The Institution of Chemical Engineers, 56 Victoria St., London, S.W.1, will be held at the Royal Institution, 21 Albemarle Street, London, W.1, at 5.30 p.m. (tea at 5 p.m.). The following paper will be presented and discussed:

CHEMICAL PROCESSING OF NUCLEAR FUELS R. Spence, C.B., PH.D., D.SC., and C. M. Nicholls, B.SC.(ENG.).

The early development of chemical processes for the military production programme is described, and a distinction is drawn between the basic requirements of this programme and those of the future atomic power programme. An attempt has been made to discuss chemical processing in general terms, and attention is drawn to some features of design peculiar to radioactive plants. The possible application of the various types of process are considered in relation to technical and economic factors such as composition of the fuel, degree of irradiation, fuel inventory, etc. It is concluded that there will be a need for versatility in processing plants for some time to come, since neither reactors nor fuel elements have been standardized, and that solvent extraction processes will be favoured over the next few years.

MARCH 5 *Tuesday*

A meeting sponsored by The Institution of Civil Engineers will be held in the building of that Institution, Great George Street, London, S.W.1, at 5.30 p.m. (tea at 5 p.m.). The following paper will be presented and discussed:

BEHAVIOUR OF RADIOISOTOPES IN SEWAGE TREATMENT AND THE DISPOSAL OF RADIOACTIVE WASTES TO SEWERS A. W. Kenny, M.A., B.SC.

The author discusses the general principles on which maximum permissible levels of irradiation are fixed and shows that, with the present use of radioisotopes, these levels are not exceeded. He discusses the contamination of drains, the hazard to workers in sewers and at sewage disposal works; the effect of radiation on sewage-purifying organisms; the behaviour of certain radioisotopes during sewage purification; the discharge of radioactive sewage effluent to rivers; and the concentration of radioisotopes in sewage sludge.

Advance copies of the papers to be read on the 21st February and the 5th March are available from the Secretary of the sponsoring Institution, not from the B.N.E.C.

SOME RECENT BOOKS

P. F. DRUCKER

THE PRACTICE OF MANAGEMENT

HEINEMANN. 363 PP. 25S.

'So help us, the old man has read a book; we used to know what he wanted of us, now we have to guess.' Peter Drucker quotes this in his book as a probable response to the manager who becomes too self-conscious in his relationships, as a result of an overdose of current management literature. That there lies wisdom behind this observation is true, as it is true that there lies wisdom behind a great deal which he has to say in this book. But the reader might be forgiven for a *sotto voce* 'Physician heal thyself'.

Although its title implies a concern with practice, this book is, to a considerable extent, concerned with theory and principles which are expounded in an academic fashion and in a language unlikely to be very meaningful to the 'run of the mill' British manager. None the less, when Mr. Drucker illustrates his points with case histories, as he does liberally, he has some fascinating stories to tell, and he draws some highly significant morals from them. His telling of the decline and revival of the Ford organization opens the second part of his book, in which he discusses 'The Management of Managers'. It is here that he comes, for the British reader, closest to the heart of the matter. 'A mean spirit in an organization will produce mean managers, a great spirit, great managers. A major requirement in managing managers is therefore the creation of the right spirit in the organization.' It is difficult, however, to avoid the impression that Mr. Drucker believes that this 'right spirit' can be created by a 'chief executive team' applying a set of principles of management having an almost scientific validity. If this impression is correct he is ignoring the immense achievements of the great 'artists' of management who 'fly by the seat of their pants' and who intuitively inspire their organizations with 'the right spirit'. Are such men really anachronistic relics of a pre-scientific management age?

Mr. Drucker's book cannot be fairly described as 'Every Manager's Guide to Management', but for those who enjoy seeing their daily job through the eyes of a highly intelligent and sophisticated observer on the touch-line, its reading is well rewarding.

P. V. HUNTER and J. TEMPLE HAZELL

DEVELOPMENT OF POWER CABLES

NEWNES. 159 PP. 25S.

The ever-increasing demand for electrical energy has presented, over the last 70 or 80 years, a growing variety of technical and practical problems to electrical engineers. Problems of increased voltage and greater current, the necessity for reducing costs, the necessity for economizing in materials, the necessity for occupying less and less space; all these, and many more, have faced electrical engineers, whether they are designers of plant and apparatus or concerned with the transmission of power from point to point. It is, therefore, very valuable to have an occasional review of the progress made in one particular field since pioneer days. Such a review is all the more valuable when it is undertaken by engineers who have themselves contributed, in no small measure, to the progress which they recount. The authors of the book under review are both well known in the electrical engineering industry and profession, and one of them, Mr. Hunter, was recognized, before his unfortunate death a few weeks ago, as an international figure in the electrical cable world. He will be long remembered for his outstanding work. The other author, Mr. Hazell, has always been extremely interested in the historical aspects of his subject and was largely responsible for the fascinating collection of cable relics now known as the 'Hunter–Hazell Collection': this is housed in the Science Museum, South Kensington.

The book itself is to be particularly commended for the easy style which the authors have achieved—a style which succeeds in presenting dull information in a lively and interesting manner. The major part of the book is concerned with cables which are now of purely historical interest. It is true that some reference is made in the last chapter to recent developments, but this chapter is so short and so sketchy that it is of very little value as a record of present practice. It is evident, therefore, that little will be gained by the serious student of cable technology other than a general appreciation of the major achievements of cable engineers over the years. This does not, however, detract in any way from the general interest likely to be aroused among electrical engineers as a whole. It is to be hoped that this work will be followed by others, setting down in the same authoritative manner preliminary developments in other branches of electrical engineering.

E. M. NOLL

CLOSED-CIRCUIT AND INDUSTRIAL TELEVISION

NEW YORK: MACMILLAN. 240 PP. 23S. 6D.

The initial devotion of the science of television to the field of entertainment has obscured the fact that it also has many important industrial uses. Developments in this second sphere are rapidly occurring and it is very appropriate that a book devoted entirely to industrial television should now appear.

The author begins with an introductory chapter which would be very readable by, say, the works manager of a factory who has heard something about the uses elsewhere of industrial television systems, and desires to know something more about them with a view to considering an installation in his own factory. In Chapters 2 and 3 the principles of television are very clearly set out but naturally require the reader to have some knowledge of fundamental electrical principles. This will be readily understandable by the chief engineer of the factory, to whom the works manager might pass the book. From Chapter 4 onwards, however, the author permits himself to go into the specific technology of television in considerable detail, and much of this material would be advanced for anyone but a specialized television engineer. Thus Chapter 4 discusses camera tubes and circuits, Chapter 5 video amplifier systems and Chapter 6 sync and deflection generators; the remainder of the book describes the existing commercial cameras, their operation and maintenance, in far more detail than is appropriate to a book of this type. Much of the material in these latter chapters must have been copied

from the operating and maintenance instructions of the various types of equipment—with what purpose it is difficult to see, since such instructions would, of course, be provided with the equipment itself. Moreover, this information relates entirely to American equipment and so would be likely to have little value in this country.

The book is well illustrated throughout with clear diagrams. On the other hand, no mention is made anywhere in the book of the costs, either capital or running, of industrial television. Admittedly it may be argued that such costs are always changing, but nevertheless some indication of present costs and their trends could usefully have been given.

F. SEELEMANN

FUNK ENTSTÖRUNG

DARMSTADT, GERMANY: OTTO ELSNER. 811 PP. £4 18s. APPROX.

As may be judged from the size of this book, its scope is much wider than would probably be anticipated from the literal translation of its title; not only does it deal with the technical problems of eliminating, as far as possible, the effects of unwanted electromagnetic field disturbances of all kinds, but it also covers many associated problems ranging from legal responsibility for interference suppression to safety precautions to protect people making field measurements near high-voltage power installations.

There are seven sections, of which the largest—comprising more than a quarter of the whole book—is devoted entirely to a general account of radio and television theory and practice, including the design of aerials and of transmitting and receiving equipment. The author includes typical circuit diagrams, and design curves and nomograms which enable practical component values to be determined. Three of the sections, forming about half of the book, are concerned with its main subject: the causes of radio interference, its detection and measurement, and the steps which can be taken, both at the source of interference and at the receiver, to minimize its effect. Detailed description, illustrated by photographs, is given of the mobile equipment used by the German Post Office for measuring radio interference and for tracking it to its source. The methods of reducing the effects of interference which are described include the fitting of suitable suppressor filters to electric traction systems, mercury-arc rectifiers, gas-discharge street lighting, rotary convertors, ignition systems of internal combustion engines, etc., and the correct use of directional receiving aerials to discriminate against unwanted radiations. The problem of avoiding interference from receiving stations themselves, particularly from television receivers, is also considered.

The remainder of the book forms a comprehensive reference section containing useful information, much of which has a general application quite apart from interference suppression.

This book, which was compiled on behalf of the German Post Office, is obviously intended to form a self-contained standard reference work, covering every aspect of its subject, and there is no doubt that the author has succeeded in this aim. Although, at present, it has no counterpart in this country, it contains little technical information that is new or is not already available from various English-language sources.

Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.

BOOKS

McILWAIN, K., and DEAN, C. E. (Editors) 621.397.3

Principles of Color Television*

New York, Wiley, 1956. pp. vii, 595. 23 × 16 cm. £5 4s.

A comprehensive work which discusses the fundamental requirements for a successful system and methods of measuring and stating colour values. It describes the transmission standards of the Federal Communications Commission and the principles of adequate transmitting and receiving equipment. The design principles of complete colour receivers are dealt with, including questions of synchronization, the video amplifier and decoders. Testing and measuring techniques are also described. This book will be reviewed in a future issue.

MALOW, W. S. 621.398

Fernmessung, Fernmeldung, Fernsteuerung in elektrischen Anlagen. (Telemetering, Telecommunications and Telecontrol in Electrical Systems)

Berlin, VEB Verlag Technik, 1904. pp. 280. 24 × 18 cm. £2 14s.

This book, translated from the Russian, is concerned with the application of remote control and supervisory devices in power supply systems and networks. Special attention is given to load dispatching in these systems and a section is devoted to planning and equipping such installations.

MORGAN CRUCIBLE COMPANY LIMITED 93 : 621.3

Battersea Works. 1856–1956

London, Morgan Crucible Co., 1956. pp. 67. 25 × 18 cm.

An interesting account of the history and development of the Morgan Crucible Co. over the first hundred years of its existence, fascinatingly illustrated throughout.

LIBRARY ACCESSIONS

MORTLOCK, J. R. 621.316.3

A.C. Switchgear. Volume I: A survey of requirements*

London, Chapman and Hall, 1956. pp. xii, 387. 22 × 15 cm. 50s.

This is not a design manual but a guide for engineers concerned with problems relating to the ratings of switchgear. It deals with the basic principles of operation of relays and various types of protection, and with the measurement of fault currents and voltages. The initiation of arcs, restriking voltage, and insulation level at the higher voltages are also discussed. Volume II will deal with details of switchgear and basic design principles.

NAGATA, T. 550.38

Rock-magnetism

Tokyo, Maruzen, 1956. pp. 230. 24 × 14 cm. £2

A Japanese work in English in which the author has attempted to give a systematic description of the magnetic properties of rock-forming magnetic oxides and other compounds of metallic and non-metallic elements. He describes apparatus for determining the magnetic properties and discusses problems in geophysics and related fields.

O'BRIEN, M. A. 413=82

New English-Russian and Russian-English Dictionary. Volume I. English-Russian

London, Allen and Unwin, 1930. pp. x, 363. 16 × 12 cm. 10s. 6d.

A useful pocket-sized non-technical dictionary designed for practical everyday use both for business and in the home. It includes both colloquial and obsolete expressions. No clue to the Russian pronunciation is given.

PRZIBRAM, K. 535.37

Irradiation Colours and Luminescence.* A contribution to mineral physics.

London, Pergamon Press, 1956. pp. xiv, 331. 22 × 14 cm. £3 3s.

This is a translation from the German. It provides an extensive treatment of the coloration in minerals and the luminescence which is associated with it.

SATTELBERG, K. 621.317.76

Anzeigende Frequenzmesser (Frequency meters)

Karlsruhe, Verlag G. Braun, 1956. pp. 160. 21 × 15 cm. 37s.

A comprehensive account of indicating and recording frequency meters, primarily those for power frequencies. The theory, development and construction of the instruments are given, with diagrams and illustrations. Some chapters on the measurement of higher frequencies, by counting-circuits and the like, are included.

SCHURE, A. (Editor) 621.396.619

Amplitude Modulation

New York, Rider, 1956. pp. vii, 56. 21 × 14 cm. 10s. approx.

Describes the basic principles and various methods used for amplitude modulation. Discusses power in the modulated wave, frequency stability and linearity.

SCHURE, A. (Editor) 621.396.615

Blocking Oscillators

New York, Rider, 1956. pp. vii, 64. 21 × 14 cm. 10s. approx.

A non-mathematical explanation of the operating features, pertinent design factors and applications of blocking oscillators.

SWALE, W. E. 677 : 621.3

Electricity in the Textile Industries*

London, National Trade Press, 1956. pp. x, 244. 22 × 15 cm. 30s.

This book is not written for electrical engineers but for mill managers and executives who wish to have some knowledge of the practical implications of the increasing use of electricity in their works, without too much technical detail. It discusses the types of motor for various purposes, public versus private electricity supply, group and individual drives, heating, light and ventilation. There is a list of references to more detailed works, and the book contains many illustrations.

THIRRING, H. 621.311.003

Power Production. The practical application of world energy*

London, Harrap, 1956. pp. 399. 14 × 21 cm. 25s.

This book contains a great many facts and figures, often in the form of diagrams and tables, of the fuel resources of the world and the rate at which they are being consumed. The author has produced an interesting and readable story without glossing over the technical details which are necessary to give it substance.

THOUREL, L. 621.396.67

Les Antennes (Aerials)

Paris, Dunod, 1956. pp. vi, 440. 24 × 15 cm. £5 approx.

An attempt to provide a synthesis of the present-day knowledge of the construction of aerials, at the same time reviewing the literature. Each chapter is followed by an extensive bibliography. Particular attention is given to aerials for decimetric and centimetric wavelengths especially in relation to radar. This book will be reviewed in a future issue.

TIBBS, C. E., and JOHNSTONE, G. G. 621.396.619

Frequency Modulation Engineering*

London, Chapman and Hall, 1956. pp. xii, 435. 22 × 14 cm. 45s.

A considerable expansion of the 1947 edition of a book intended to give a concise and not too mathematical survey of the subject. It discusses the basic properties of frequency modulation, propagation in the ultra-short waveband, and aerials. Interference, noise structure, and interference suppression in an f.m. system are dealt with in some detail. The remainder of the book is devoted to technique and circuits for transmission and reception. This book will be reviewed in a future issue.

WIRK, A., and THILO, H. G. 621.317

Niederfrequenz- und Mittelfrequenz-Messtechnik. (Low- and Medium-Frequency Measurements in Telecommunication)

Stuttgart, S. Heizel Verlag, 1956. pp. viii, 234. 23 × 15 cm. £2 10s. approx.

This book deals with frequency measurements in the low and medium range and is complementary to Hochfrequenz-Messtechnik by O. Zinke, which dealt with frequency measurements above the audio-range. It includes some photographs and circuit diagrams of commercial apparatus.

OTHER PUBLICATIONS

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Automation in Perspective

London, H.M.S.O., 1956. pp. 26. 22 × 14 cm. 1s. 6d.

BRITISH BROADCASTING CORPORATION

An Automatic Integrator for Determining the Mean Spherical Response of Loudspeakers and Microphones

London, B.B.C. Engineering Division, Monograph No. 8, 1956, pp. 16. 28 × 22 cm. 5s.

METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED

Control of D.C. Machines

Manchester, Metropolitan-Vickers, 1956. pp. 24. 28 × 21 cm.

MINISTRY OF HEALTH

Report of a Working Party on Anaesthetic Explosions Including Safety Code for Equipment and Installations

London, H.M.S.O., 1956. pp. v, 39. 24 × 15 cm. 2s. 6d.

MINISTRY OF LABOUR AND NATIONAL SERVICE

Scientific Manpower in Great Britain. A report on the number and distribution of scientists and engineers now employed in Great Britain, and a study of the likely trend in the future demand for scientific and engineering manpower.

London, H.M.S.O., 1956. pp. 28. 24 × 15 cm. 1s. 6d.

MINISTRY OF LABOUR AND NATIONAL SERVICE—FACTORY DEPARTMENT

Electrical Accidents and Their Causes, 1954

London, H.M.S.O., 1956. pp. 60. 24 × 15 cm. 3s. 6d.

NATIONAL PHYSICAL LABORATORY

Application of Spring Strips to Instrument Design. Notes on Applied Science, No. 15

London, H.M.S.O., 1956. pp. iv, 25. 24 × 15 cm. 2s.

High Voltage Impulse Testing. Notes on applied science, No. 17

London, H.M.S.O., 1956. pp. iv, 9. 24 × 15 cm. 1s. 6d.

Units and Standards of Measurement Employed at the National Physical Laboratory. I. Length, Mass, Time-Interval, Volume, Density and Specific Gravity, Force and Pressure

London, H.M.S.O., 1956. pp. 14. 24 × 15 cm. 1s.

UNITED NATIONS—ECONOMIC COMMISSION FOR EUROPE

Rural Electrification. Vol. 1

Geneva, United Nations, 1956. pp. 98. 28 × 22 cm. 5s. 6d.

RHODESIA

Electricity for the Copper Belt

The world-wide expansion in the use of electricity since the Second World War has, not unnaturally, had its effect on the copper-mining industry in the Copper Belt of Northern Rhodesia—the largest copper-producing area in the British Commonwealth.

Since 1945 the large copper mines of Rhokana Corporation—Roan Antelope, Mufulira and Nchanga—have been operating at full pressure and the continued prosperity of the industry has led to the development of additional mines in the vicinity, namely Bancroft and Chibuluma, with others to follow.

It is not surprising, therefore, that this expansion should have an effect on the demand for electrical power, and in fact the Copper Belt has experienced an acute power shortage during the post-war years.

Up to the present, power has been derived from thermal stations located at the four large mines, dependent on coal from Wankie, some 560 miles to the south. These power plants were not interconnected initially, and the provision of additional plant at each mine to meet the increasing load would normally have been necessary.

In order to effect economies in the provision of plant and to provide additional security, the copper-mining companies took a decision in 1948 to interconnect their power resources by means of a 66 kV network, and a subsidiary company, now known as the Rhodesian Congo Border Power Corporation, was set up for the purpose. Additional thermal plant required to meet the increased load was installed at only one mine—Nchanga—the additional equipment comprising five 15 MW sets using steam at 650 lb and 850° F.

Thermal generation was, however, complicated by an utterly inadequate supply of coal, and in order to maintain production, extensive wood burning was introduced, the terrain, fortunately, being provided with well-wooded areas from which to draw supplies. This practice proved expensive and inefficient, but was a successful makeshift for the time being.

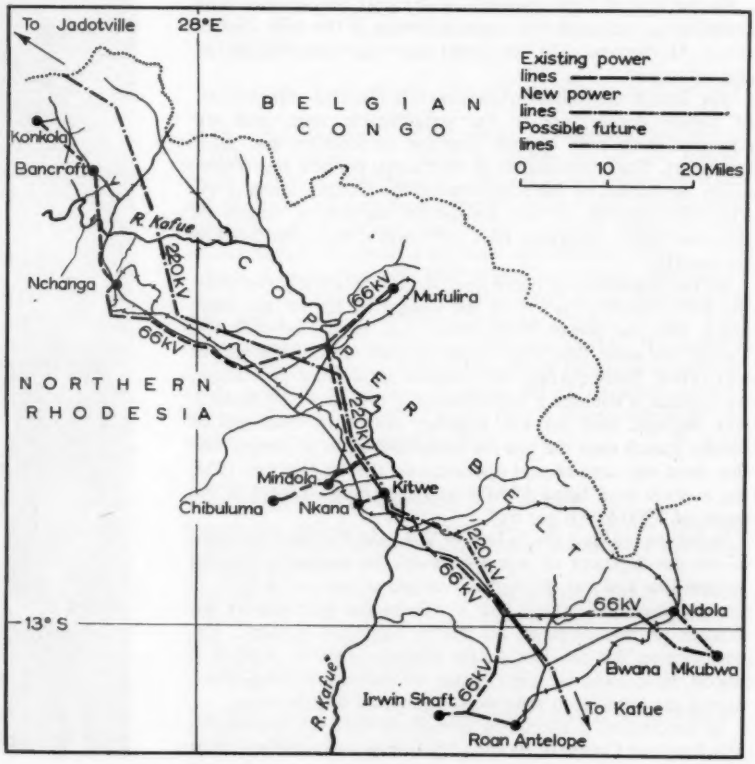
In spite of these provisions, the electrical load forecast was still increasing at the rate of something like 15% per annum, and as the question of increased supplies of coal remained extremely doubtful, the Power Corporation was forced to look elsewhere for its resources. At the time no decision had been taken as to whether the Kafue or Kariba schemes would proceed. The Corporation, therefore, decided to seek a source of power in the Belgian Congo. With the collaboration of the authorities in that country, an agreement was reached in 1952 to supply the copper mines with power from a new hydro-electric station to be constructed on the Lualaba River, some 320 miles from the copper belt.

Working in conjunction with the Belgian authorities, the Corporation's consulting engineers placed the necessary equipment on order in 1953, and construction began in Rhodesia in 1955. In the meantime, progress was well maintained at the hydro-electric station in the Belgian Congo, and by the early part of 1956 it was apparent that the scheme was so well advanced that power could be expected from the Congo in September 1956—some four months earlier than was planned.

The terminal of the Congo supply is the central switching station at Kitwe, where the control organization of the Corporation's network is located, and from which 66 kV lines radiate to each of the mines.

The equipment installed there comprises 220 kV air-blast switchgear, two 60 MVA 220/66 kV transformers, and two 20 MVAr synchronous condensers, together with the necessary extensions to the 66 kV substation. In order to accommodate the very considerable increase in control equipment a new multi-storey control building was constructed.

The revised programme of construction, drawn up to meet



1 *Supply network in the Copper Belt*

2 *Switching station at Kitwe*

The 220 kV switchgear is on the extreme left, the main 66 kV switchgear is in the centre, and the new control building is on the right centre.

a date of August 1956 instead of the end of the year, is perhaps of interest. The civil works for the extensions were begun in November 1955 and were completed by March 1956, which coincided with the arrival of the major items of equipment. The first 60 MVA transformer, involving a shipping load of 100 tons, arrived at a South African port in January and was on site by the end of March.

By the end of June assembly of the gear was approaching completion, including the commissioning of the new control room. All the new gear was tested and made alive before the end of August.

The 220 kV transmission line deserves mention. The towers, of Italian design, are of the semi-flexible type, and are equipped with twin copper stranded conductors and glass insulators. The construction of the Congo portion was undertaken on behalf of the Corporation by Congo contractors. The construction of the Rhodesian section—a length of fifty-two miles—began in June 1955 and it was completed in six months.

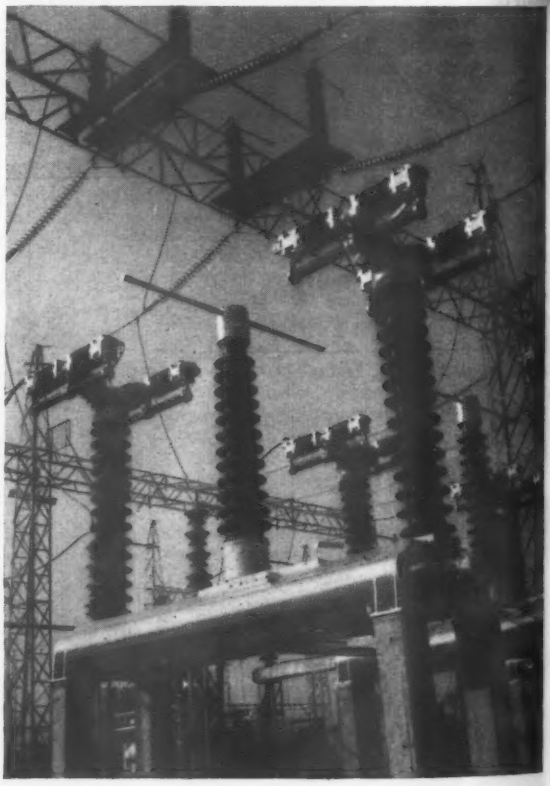
At the beginning of September the entire 220 kV line from the hydro-electric station in the Congo to Kitwe was energized, and the power Corporation was paralleled with the Congo the same day, after which a small amount of power was taken. Subsequently the distance impedance protection, with which is coupled a high-frequency inter-tripping feature, was brought into service, together with two channels of carrier speech over the line for communication purposes. The line went into commercial operation on the 1st October 1956, the average load being 55 MW and the energy import of the order of 1 200 MWh per day.

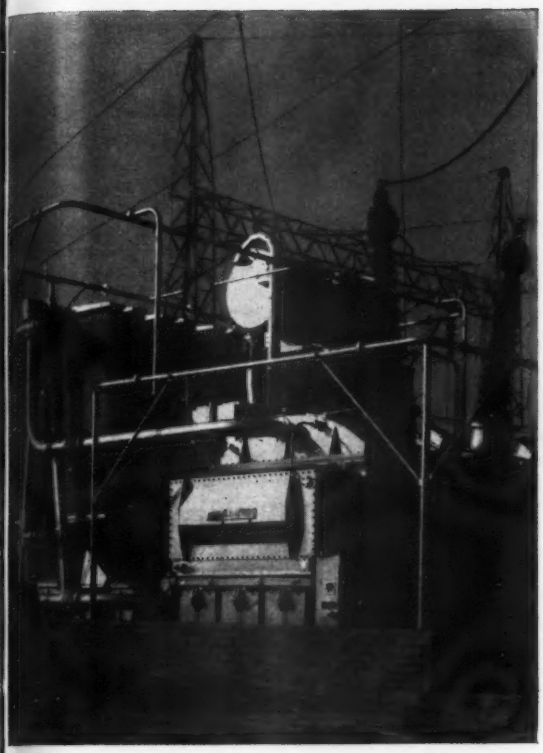
It will be realized that a link of this kind has been an event in the development of this portion of the territory. It is the longest line and has the highest voltage of any so far built on the continent of Africa, and it will be the first line at this voltage to be subjected to intense lightning activity. The performance of the line under these conditions will, it is hoped, be assisted by single-phase automatic reclosing, which during the initial tests appeared to function satisfactorily.

In conclusion, it should be mentioned that valuable as this link from the Congo is, its capacity will be absorbed and there is likely to be a further power crisis at the end of the present decade—until the position is relieved by supplies from the Kariba hydro-electric scheme at present under construction.

R. S. A.

3 *A 220 kV air-blast circuit-breaker at Kitwe*





First 60 MVA 220/66 kV transformer at Kitwe

BASRAH

IRAQ AND PERSIAN GULF JOINT OVERSEA GROUP

A State of Expansion

The first meeting of the new session was held at the Shatt-al-Arab Hotel in Basrah on the 25th October 1956. Although several of the local members were unable to be present, the attendance of thirty-two members and guests was the largest at a meeting in Basrah since the Group was formed. Mr. J. D. Addison gave his Chairman's Address on *Electrical Development in Kuwait*, and was installed in the chair by Mr. R. C. Kelt, Past-Chairman.

Mr. Addison outlined the history of electricity supply in Kuwait since 1934, and discussed fully the problems that have faced the Department of Electricity since the Government of Kuwait became responsible for electricity supply in July 1951.

The rapid rise in wealth derived from oil royalties and profit-sharing agreements occurred in Kuwait earlier than in other parts of the Middle East, and owing to the relatively small population, the impact on electricity supply has probably been more severe than in other places.

The maximum demand trebled itself in each of the first two years since nationalization, and increased over fortyfold in the period of five years. During this period over 60 miles of 11 kV cable and over 150 miles of low-voltage cable were laid, to say nothing of 11 kV and l.v. overhead lines in parts of the town where development is pending, and in outlying areas.

Prior to commissioning of the present steam-turbine power station, the peak demand at one time reached 96·7% of the total installed Diesel-alternator capacity, without allowing any margin for de-rating engines working in ambient temperatures of 120° F, or for overhauls or outages. All this was at the end of a 7000-mile sea haul from European manufacturing centres, and during a considerable period in which supplies took up to eighteen months to translate a recognized need into materials on site.

Development in Kuwait, both electrical and otherwise, continues, and is now being followed by considerable programmes of public works in neighbouring states.

The meeting was followed by a dinner to which twenty-two persons sat down.

Dates to Remember

On the next day, members, their ladies and guests visited the grading, packing and fumigating plants of the Iraq Date Trading Association and of several of the date exporting firms. Everybody was impressed with the high standards of hygiene attained, and the way in which local female labour is adapting itself to factory conditions. Grading, weighing and packing are done on an assembly-line basis with continuously moving conveyer belts, and fumigation by steam or methyl bromide is carried out on a batch basis. All packed dates are subjected to a vacuum immediately before admission of the fumigant. Iraq dates are among the world's best, and during a good season some 280000 tons are exported to most parts of the world, representing about 85% of the exports of all date-producing countries. J. A. C. K.

LAGOS

WEST AFRICAN JOINT OVERSEA GROUP

On the 28th September 1956, some 35 members and guests attended a meeting in Lagos at which Mr. F. H. Jaekel, Deputy Chief Superintendent (Power) of the Nigerian Railway Corporation presented a paper on *Operation and Running Maintenance of Locomotives on the Nigerian Railway*. This was excellently illustrated by films and lantern slides.

Some 60 members and their ladies and guests were entertained on the 12th October 1956 to a film show presented by B.P. (West Africa), at the Exhibition Centre, Lagos. Two documentary films, both in colour, were shown: *We found a Valley*, which covered the building of the crude oil refinery at Little Aden, and *The New Explorers*, which recorded some of the exploration for new oil fields that is being undertaken in various parts of the world to-day. E. W. F.

OVERSEA ATTENDANCE REGISTER

During the period 1st November to 30th November 1956 the following members called at the Institution building and signed the Attendance Register of Oversea Members:

BILIMORIA, P. D. (Poona)
BOND, G. (Port Louis, Mauritius)
COATES, A. G. (Homs, Syria)
DALAL, M. K., B.SC. (Bombay)
HARMER, L. B. (Hamilton, Bermuda)
McDONALD, F. G., B.SC.(ENG.) (Sydney)
OLD, J. (Kuala Lumpur)
SAVORY, A. B. (Nairobi)
SIMPSON, R. M. O. (Durban)
WALDRAM, A. H. T., B.SC.(ENG.) (Zomba, Nyasaland)
WILKINS, J. H. (Aden)

MEMBERS LIVING OR TRAVELLING OVERSEA

Please read notices on p. 52 of this issue.

LONDON REPORT

ORDINARY MEETING

The sombre political atmosphere of the day had no adverse effect on the attendance at Mr. J. Eccles's lecture on the three-weeks' tour of the electricity supply delegation to Russia in April and May 1956. At the ordinary meeting on the 8th November the auditorium was filled and the audience remained interested and undisturbed for two and a half hours. Mr. Eccles outlined the experiences of the delegation on their visit to Moscow, to the Urals and the Black Sea area, and to Leningrad. The address was illustrated by slides and was illuminated by the sparks of humour which the members of The Institution have come to expect from their Past-President. This report deals mainly with the discussion, since the address itself will be published, substantially in full, in a future issue of the *Journal*.

A film, with English commentary, taken during the visit of the delegation, was exhibited at the close of Mr. Eccles's address and was received with great interest.

The discussion which followed the address was opened by Sir John Hacking, who had recently returned from Russia, where he had led the hydro-electric delegation. Sir John confirmed, from his own experience, a number of the points made by Mr. Eccles and referred especially to the enormous power resources of the country. Estimates place these resources at about 1 500 billion kW hours, which corresponds to 375 million kilowatts at 45% load factor. Even with the enormous programme which is now planned for completion by 1960, the U.S.S.R. will still be using less than 5% of its potential hydro output.

Lord Citrine made a number of interesting comments comparing the Russia of to-day with the Russia he had visited in 1943. One outstanding impression was that, whereas on the earlier visit the people had been most anxious to avoid talking to foreign visitors, they had on this last occasion seemed anxious to talk, to obtain information about conditions of living and working in the outside world, and to communicate their views on the many social and technical problems with which they are now faced. Mr. E. A. Logan asked about the application of electricity in the domestic sphere and was advised by Mr. Eccles that the emphasis is almost entirely on the industrial load; the domestic consumer is not encouraged, either by publicity or by the availability of supplies of domestic electrical apparatus.

Railway electrification was the subject of a question from Mr. F. S. Edwards. Mr. Eccles said that although it had seemed that appreciable progress was being made with electrification in the south of the country, the majority of the railway system comprised single-track routes, steam operated. In response to a question from Mr. B. Rabbetts on what the party had seen which was novel to western practice, Mr. Eccles referred to a continuous automatic process for welding semi-circular steel plates 3 inches thick and 12 ft in diameter. He also described a coil-wrapping machine for insulating stator coil ends. Mr. H. West, who had also been with Sir John Hacking's party, gave his impression of Russian manufacturing works that showed evidence of lack of experience both in general arrangement and in organization. He, also, had noted the coil-wrapping machine as the best technical device on view.

F. J. L.

MEASUREMENT AND CONTROL SECTION

Radioactive All

The meeting on the 9th October 1956 was honoured by the presence of the President and of six Past-Chairmen of the Section. As the retiring Chairman, Mr. W. Bamford, remarked, this showed an interesting adhesion. Perhaps the President provided a clue to this when he said that the Measurement and Control Section runs at the very core of The Institution's interests, and that those at the very spearhead of development are dependent on measuring instruments and measuring techniques.

The new Chairman, Dr. Denis Taylor, chose as the subject of his address *The Measurement of Radioactivity*. A summary of the address is given on p. 9. Some interesting facts emerged which showed the delicacy of measurement possible by using radioactive techniques. In certain cases, analysis by atomic disintegration can be measured at such a low rate as one count per hour against a background of a similar order. This technique provides an extraordinarily sensitive method of analysis involving microscopic quantities of material undetectable by other means.

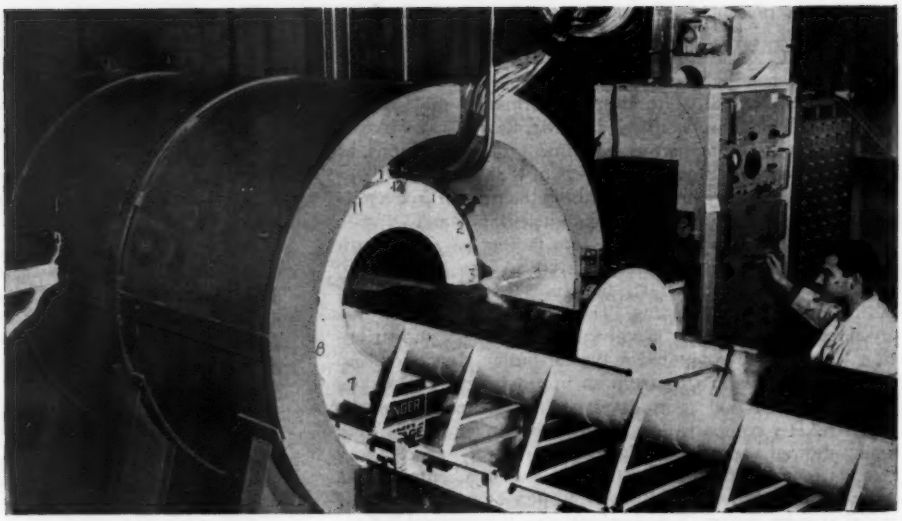
Some interesting investigations have been made, including the measurement of body radioactivity, a very important subject for those working with radioactive substances. In order to avoid misleading background radiation, investigators in this field have taken their victims far underground in granite caves to avoid cosmic radiation, or have propelled them on stretchers into some pieces of equipment vaguely reminiscent of a horror camp (Fig. 1).

It may not be widely known that the human body is radioactive, and constantly emits about 1×10^{-8} curie of gamma radiation. Figures were not provided to show how one's personal radioactivity is related to age, sex, state of health or habits, nor was it clear whether it was something to be proud of or self-conscious about. Although not stated, members of the audience must have been aware of the fact that each was irradiating the rest, and here perhaps was another hazard of the crowded room or of the cup final.

Dr. Taylor then turned his attention from human bodies to carrot tops, and revealed that this vegetable had undergone some careful tests for radioactivity; apart from the naturally occurring potassium 40 there were some shorter-lived radioactive elements of cerium, iodine and ruthenium. No profound significance should be attached to the fact that carrot tops were the subject of the investigation; it was assumed that there was some form of connection with the daily menu. This additional radioactivity resulted from atmospheric 'fall out', but to reassure those who consistently blame atomic physics for all the evils of the day (including the weather), Dr. Taylor stressed that the radioactivity of the carrot tops was several orders of magnitude below the maximum permissible level laid down by the International Committee on Radiological Protection. In order to show the persistence of radioactive 'fall out', Dr. Taylor cited the case of milk powder which had become radioactive in the first place from pasture land.

From the garden into the home, and here Dr. Taylor and his colleagues found that vacuum cleaner dust showed the presence of radioactive zirconium, caesium, ruthenium and potassium. Again this was due to the microscopic radioactive 'fall out'. In fact, the sensitivity of these measuring techniques allowed remote recordings to be made of the start-up and shut-down of the Harwell reactor Bepo.

A vote of thanks was proposed by Professor C. Holt-Smith,



1 *Apparatus used in the United States for the measurement of the radioactivity of the human body*

By courtesy of Dr. E. C. Anderson, Los Alamos Scientific Laboratory

who drew attention to Dr. Taylor's success in two fields of activity—radar and atomic energy, both initially secret projects, a common link being provided by pulse techniques.

At this point in the proceedings, Mr. Bamford ceded the chair to Dr. Taylor. Mr. C. Ryder proposed a vote of thanks to Mr. Bamford for his most successful year of office, which, said Mr. Ryder, started off so well with the Chairman's Address and covered an extremely successful convention on computers. Mr. D. Edmundson seconded the proposal, and complimented Mr. Bamford on his breadth of knowledge, tact, and charm in presiding at meetings. The meeting enthusiastically supported the motion, and Mr. Bamford's year of service ended on a happy note with the new Chairman presenting him with an engraved certificate of chairmanship.

R. S. M.

Annual Dinner

The Annual Dinner of the Measurement and Control Section was held at the Café Royal, London, on the 13th November 1956. Dr. Denis Taylor presided.

In proposing the toast of the Measurement and Control Section, the President, Sir Gordon Radley, said that he felt he was repaying a debt which he had owed since the time he was Chairman of the Section. The Section had come to life in 1928 as the Meter and Instrument Section, concerned with rather sordid methods of collecting money and measuring electricity, but with the presentation of papers on precision measurement it had since entered into a period of higher thinking and had added materials and control to its scope; Sir Gordon wished the Section a very successful Session.

Dr. Denis Taylor, in his reply, said that the President and his Department had done much to foster the growth of the Section, and the members in their turn would wish him a pleasant and successful term of office as the President of this great Institution. In association with the Radio and Telecommunication Section an important Convention on Ferrites had recently been held, and the Committee had a well-developed programme of papers for future meetings. With the widened scope of the Section and the rapid developments in electrical science it was difficult to plan a balanced programme of appeal to all members of the Section, and at the same time to ensure the inclusion of specialist papers on the new aspects of measurement and control which were coming into being. He thanked the President both for his presence and his good wishes.

The toast of the guests was proposed by Mr. H. S. Petch, Vice-Chairman of the Section, who welcomed Sir Henry Tizard and Dr. G. B. B. M. Sutherland, Director of the National Physical Laboratory. The Institution had a very high regard for the National Physical Laboratory, which had for a long time been represented on the Section Committee, and two of its members had reached the chair. Many valuable papers had been received from that source, which had also given much assistance during the Convention on Digital-Computer Techniques. In expressing his pleasure at seeing at the Dinner the Chairmen or Vice-Chairmen of the other Specialized Sections, Mr. Petch said that the Measurement and Control Section was in the nature of a bond linking the wide and diverse interests of The Institution.

In reply, Sir Henry Tizard said he was happy to be present and to see one of his old colleagues in the chair. He had always been keenly interested in electrical engineering and in the conditions for scholarships in engineering research. We were living in extraordinary times, and in the state in which we find science and technology to-day, there was a danger that we might always be short of scientists and technicians. We should do well to adopt Rutherford's method, and say to the man who is doing the work, 'Why are you doing it?' In this way we could make sure that each of our limited number of scientists was employed efficiently, and that use was not being made of first-class men on matters of second-class importance.

There was an attendance of 269 members and guests at the Dinner, and the enjoyable function concluded with a short entertainment by Mr. Michael Bailey.

RADIO AND TELECOMMUNICATION SECTION

Research on H.F. Radiotelegraphy Reception

At the Radio and Telecommunication Section Meeting on the 14th November 1956, a co-ordinated series of six papers dealing with research into the reception of h.f. telegraph

signals was presented. The authors, Messrs. H. B. Law, J. W. Allnatt, E. D. J. Jones, F. J. Lee, R. C. Looser, F. A. W. Levett and C. G. Hilton, under the leadership of Mr. Law, have been engaged on research into fading, frequency diversity, detectability, receiver performance and related topics. The papers were surveyed by Mr. Law, who employed a short film and numerous equipment demonstrations to illustrate the more interesting aspects of the work.

Mr. Law began by briefly describing the present frequency-shift technique for long-distance radiotelegraphy and went on to describe the authors' research into fading. Several recordings of two-tone signals were played to the audience to demonstrate slow and fast, flat (non-frequency selective) fading and selective fading. The speaker stated that the envelope of a fading c.w. signal followed a Rayleigh distribution law, and he compared a typical fading signal received from Australia with that from an improved artificial-fading machine which had been developed in the course of the research. His comparison was aided by an interesting film which showed a spot travelling about the screen in such a way that its polar co-ordinates with respect to the centre of the screen represented the amplitude and phase of the r.f. fading signal at every instant. It was evident that the artificial-fading, although not identical in character with that of the natural signal, was a sufficiently good simulator to enable equipment research to be carried out.

Mr. Law dealt with the frequency spectrum resulting from the mark-to-space transition, and pointed out the need for high transmitter and receiver frequency stabilities, and optimum receiving filters. He then came to the central point of the main paper, namely that a two-tone selective-fading signal already incorporates frequency diversity, but that ordinary receivers do not take advantage of this feature. When the fading is frequency selective and slow compared with the signalling speed (the prevalent condition), the full telegraphic information is present in either mark or space signals. By using a circuit called the 'assessor', Mr. Law and his colleagues are able to combine the information from mark and space channels and other space-diversity branches in the optimum way.

To prove their point the authors provided a convincing demonstration in which 10000 mark and space elements of telegraph signal were passed over a telephone line to the new fading machine at the G.P.O. Research Station, and then returned to The Institution over another telephone line. The test was carried out by counting the number of elements received in error (in the presence of white noise), a technique which the authors have developed to the point of providing accurate statistical results. With flat fading the number of errors indicated was 82. With frequency-selective fading, the diversity action between mark and space channels caused the errors to be reduced to only 10.

Mr. Law concluded by asking the ionospheric physicists to continue with the study of the causes of fading, because further improvements in radiotelegraphy will depend on a better understanding of such factors.

The discussion was opened by Mr. A. W. Cole, who felt that the authors had made such a contribution that the scope for further improvement was rather limited. He referred to work carried out many years ago by engineers of Cable and Wireless, which was similar in many respects to the present receiving technique. Instrumental difficulties at that time prevented the adoption of the technique. He stated that his company was now experimenting with this type of reception for v.h.f. scatter-type signals.

There followed an interesting series of contributions from several speakers. The audibility of some of the speakers came in for some light-hearted comment, and it was evident that the polar diagram of the speaker's microphone was not always being used under conditions of maximum gain. Capt. C. F. Booth referred to the importance of frequency stability and mentioned that the C.C.I.R. were proposing to halve the frequency instability tolerance within five years. He commented upon the scientific method of attack used by the authors and put forward a plea that they should continue with this important research. Mr. V. J. Terry remarked on the thoroughness of this research and admired the way in which the authors had turned an enemy (selective fading) into a friend. Mr. Smale, whose earlier complaint about inaudibility was turned upon him with good effect, went on to attack the authors' reliance upon experiments with white noise. In practice he said the white noise was swamped by general interference. Mr. Law, for the authors, admitted that the character of noise on h.f. circuits was such as to tend to reduce some of the diversity gain found with white-noise experiments. Finally Dr. R. L. Smith-Rose spoke for the ionospheric physicists and assured the authors that the study of fading would continue.

Dr. R. C. G. Williams, the Chairman of the Section, moved the vote of thanks. He remarked that it was unfortunate that the immediate Past-Chairman, Mr. H. Stanesby, was unable to be present, for Mr. Stanesby had done so much to institute the programme of work described so clearly during the evening.

E. V. D. G.

SUPPLY SECTION

'Economy, Efficiency and Expediency'

To aim at economy and efficiency is always respectable, although possibly uncomfortable; but in some circumstances expediency has a somewhat pejorative connotation, as implying some departure from accepted principles in the interests of a comfortable life. The many members who attended the Supply Section's opening meeting of the new session on the 24th October learned from the new Section Chairman that expediency in its engineering sense is entirely admirable. It denotes the satisfaction of all those requirements, explicit and implied, which cannot be formulated in numerical terms and are sometimes contrary to the dictates of economy and efficiency.

As is usual at an opening meeting, the normal masculine solemnity of the lecture theatre was relieved by the presence of a number of ladies, who obviously enjoyed the proceedings. The audience included Mr. T. G. N. Haldane, Mr. and Mrs. S. E. Goodall, and the President, who made a short and happy speech. He had been taxed with failing to become a member of this most important Section; pleading guilty, he wished account to be taken at the same time of another misdeed—the theft some years ago of the Section's senior premium. He had doubtless been led away by bad company. The point might be made, however, that if attenuation worked in reverse he would control, in the transatlantic telephone cable, the most powerful generating system in the world.

Mr. L. Drucquer, the retiring Chairman, introduced his successor, Mr. P. J. Ryle, who delivered his inaugural address. This address, a summary of which appears on p. 10, was a masterly exposition of the complicated interplay of requirements which go to determine engineering design, and of the

manner in which judgment must be exercised to satisfy them. Just as important as those requirements set by function may be those imposed by less obvious influences such as the elements, and human preferences both individual and as expressed by 'antibodies'.

The lecture was delivered with calm precision, and illuminated not only by striking illustrations of the various points made, but by shafts of humour so unobtrusive that each kept the audience on tenterhooks lest they missed the next. The lecture itself, as a distillation of experience, was entrancing, and the text of it would well repay study by new entrants to the profession.

The vote of thanks was proposed by Mr. D. P. Sayers, who remarked on the fact that some of the influences which were a nuisance to the engineer were beneficial from other points of view: antibodies had useful functions in physiology, and perhaps in the body politic.

Mr. Ryle's first action on taking the chair was to call on the President for a short address, and then on Mr. J. D. Peattie and Professor M. G. Say respectively to propose and second the vote of thanks to the retiring Chairman.

As members of the Section were well aware, Mr. Drucquer had carried out his duties with efficiency and charm, and had not shrunk from the vast calls on his time which the office of Chairman now imposed. He had been excellently supported by Mrs. Drucquer, both in co-operation in those activities which she could share and by forbearance over those which she could not. Mr. Drucquer's reply indicated that the pleasure he had found in his year's service had been greatly enhanced by the willing co-operation of the members of the Section.

L. G.

DISTRICT MEETING AT OXFORD

Many new faces were in evidence at the meeting held at the Oxford offices of the Southern Electricity Board on the 14th November 1956, when we welcomed members of The Institution of Production Engineers as guests. A paper entitled *Automation and Electronics in Industry* was read by Mr. Frank W. Highfield.

Mr. Highfield covered the history and development of electronic control and servo mechanisms and then dealt with the more practical side of the applications of these devices in industry.

The car industry is using transfer machines to an ever greater extent, especially for engine machining. New problems have been introduced with the use of these machines and even the methods of sharpening drills have had to be investigated.

It is now possible to translate measurements and set up machines direct from drawings. The method of storing the information is by various means, e.g. by punched cards and magnetic tape. Mr. Highfield pointed out the need for having a standard method for the transfer of essential work to different factories, even if a particular factory should be destroyed in wartime.

The speaker believed that Britain is lagging behind in her car industry, because manufacturers who are capable of producing the necessary high-pressure hydraulic systems are fully occupied in other directions.

The interest evoked by the paper was shown by the wide range of questions asked, and eventually the meeting had to be called to a close by Mr. J. L. Taylor, the chairman.

A vote of thanks was proposed by Mr. J. W. Pringle, Chairman of the Oxford Branch and Southern Region of The Institution of Production Engineers.

W. T.

NEWS *from the Centres*

BROCKENHURST AND SOUTHAMPTON

SOUTHERN CENTRE

A Careers Exhibition

The Institution has produced a stand for use at careers exhibitions which shows some of the opportunities in electrical engineering that are open to boys and girls who wish to make it their career. This stand has been set up at a number of careers exhibitions arranged by Rotary in various parts of the country. In the Southern Centre it has successfully been shown at a careers exhibition at Bognor Regis and will again be seen at Portsmouth in May this year. Another particularly worth-while use of it occurred at the Brockenhurst County High School's first careers week, which was held in July 1956. The school is one of the few grammar schools in the New Forest.

The Headmaster had asked that all stands should be manned on the last day only. This was an open day, on which the boys and girls brought their parents. During the preceding week the students could inspect the exhibits at their leisure without being subject to salesmanship.

This arrangement seemed to work very well, if one judges from the constant stream of inquiries that were dealt with by the volunteers from the Southern Centre who represented The Institution on the stand. The Institution members present (who were all Chartered Electrical Engineers) were drawn from manufacture, utilization, distribution and generation, the senior member being Mr. L. H. A. Carr. His experience on the Examinations Committee of The Institution was invaluable in advising parents, boys and girls, on the necessity for obtaining Corporate Membership of The Institution, as the recognized qualification in the electrical industry.

There were many displays, including those of the Armed Services, marine and shipbuilding trades, the mercantile marine and several manufacturers; but it was satisfying to find that The Institution's stand was admired by the other exhibitors for its attractive yet dignified design. This opinion was also voiced by several of the staff of the school, one of whom, Mr. W. G. Lee, took the photograph shown on the next page.

It was encouraging to find that so many parents paid more attention to the importance of their children starting in careers where they could follow their natural bents, instead of going into 'dead end' jobs with an initial higher monetary return.

H. W. H.

London and South-Western

More than usual interest in an Institution paper was roused in Southampton on the 17th October 1956 by the presentation of the paper by E. L. E. Wheatcroft and H. H. C. Barton on *The Potentialities of Railway Electrification at the Standard Frequency*. A certain sentimental attachment to the steam locomotive was evident in the discussion, to which civil and mechanical engineering aspects of the problem of railway electrification were introduced. Also expressed was the hope that Southampton might soon share the benefits of an electrified rail connection with London.

E. A. L.

A group of engineers in the Staff Common Room at Southampton University, after the meeting of the Southern Centre on the 17th October

Left to right: Dr. L. G. A. Sims, Mr. H. Robson, Mr. G. M. Thompson, Mr. H. H. C. Barton, Mr. E. L. E. Wheatcroft and Professor A. N. Black.

DISTRICT MEETINGS AT WEYMOUTH

A Good Record

The area of the Southern Centre is extensive and this makes necessary the holding of meetings at numerous widely separated places. Weymouth, near the boundary of the Centre, has a good record for arranging, with Dr. J. H. Mole as convener, a sequence of formal and informal discussions throughout the session. Typical of these is a meeting held at the South Dorset Technical College, where Dr. J. H. Mason lectured on *The Breakdown of Electrical Insulation* to local members of The Institution. The experience for this lecture was gained over many years at the E.R.A. laboratories in research. This and similar research on insulating materials has made possible very substantial reductions in the size of all classes of electrical equipment, in particular high-voltage equipment. A second example is the lecture by Mr. B. Shackel, which was concerned with the human aspects of engineering and pointed to improvements in instrumentation and control achieved by studying the psychology of the human operatives.

E. A. L.

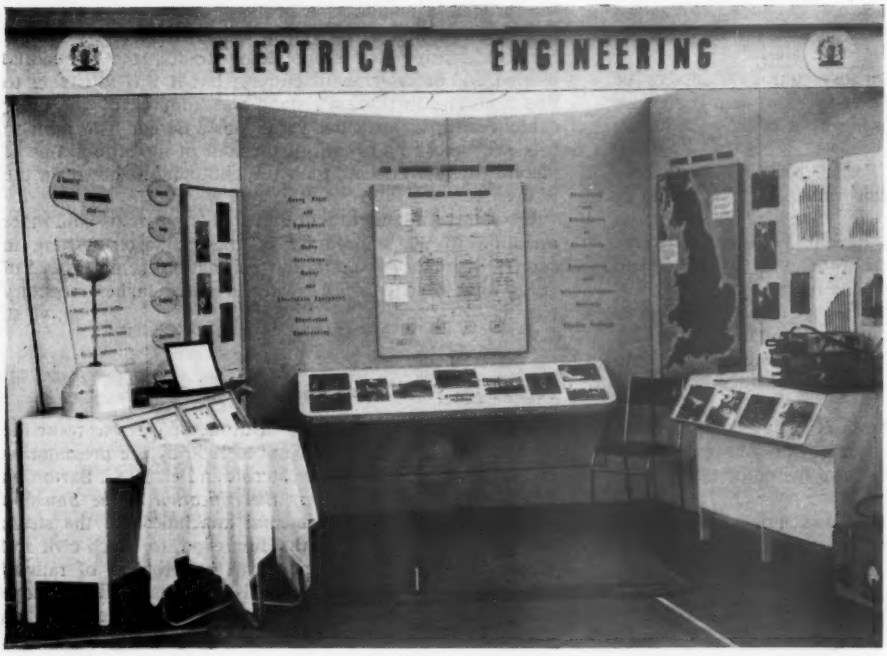
SWANSEA

WEST WALES (SWANSEA) SUB-CENTRE

Electrified Plants—The Ant and the Grasshopper

The first meeting of the session was held in the conference room of the South Wales Electricity Board on the 11th October 1956, when Mr. J. L. Griffiths gave his Chairman's Address. He reviewed the electrical developments in the coal and steel industries over the last twenty-five years. In order that his paper might be of local interest he made particular reference to activities in South Wales.

He traced electrical development in the mines from the time of the depression of the early thirties, when lack of capital limited major modernization schemes, and illustrated how nationalization of the coal mines had accelerated the rate of electrification. Owing to the drift of labour from the pits to more attractive occupations, the present level of output could not have been held without increased mechanization, and as a result there has been a spectacular increase in the use of electricity for conveyers and loaders. It is of interest to note that, whilst twenty-five years ago, owing to the limited power-station capacity available, most winders were of the Ilgner



The Institution's careers stand

[See report on previous page]

type, the national Grid of to-day can readily deal with the peak loads imposed by an a.c. winder, and new Ilgner sets are now almost unknown.

Unlike the relatively steady progress in the coalfields, that in the steel industry was in a few large jumps, when a series of new or modernized plants appeared. By these major projects, the South Wales steel and tinplate industries have been revolutionized and established once more in their fully competitive position in the world markets.

Celtic Education sets the Pace

The Annual Dinner and Dance was held on the 26th October at the Langland Bay Hotel, where members were delighted to welcome Mr. S. E. Goodall, a Vice-President. Mr. Wynne Lloyd, Chief Inspector of Schools in Wales, who proposed the toast of 'The Institution', spoke of the contribution towards the supply of scientists and technicians being made by Welsh schools and colleges. He referred to a recent report which stated that the country would need to double the number of mathematicians and scientists in universities and technical colleges in the next fourteen years. Lest this should seem an impossible task, he mentioned that in the Welsh grammar schools the results of the 1955 advanced level examination for the G.C.E. showed that three times as many students passed in applied mathematics and twice as many in science and mathematics, compared with the numbers seventeen years ago. In Wales, twenty new technical colleges or major extensions had been completed since 1945. He appealed for a new spirit in technical education, incorporating a unity of liberal and technical studies.

Mr. Goodall, who replied to the toast, recounted some points of interest in recent studies of Russian educational methods. Members were intrigued to hear of pay for students, and recruitment into the less attractive branches of industry by suitable adjustment of salary level.

The toast of 'Our Guests' was ably proposed by Mr. J. H. Groocock, to which the Mayor of Swansea, Councillor G. H. Libby, made a scintillating reply. The toast of 'The Chairman' was proposed by Professor G. H. Rawcliffe, Chairman of the Western Centre, and Mr. Griffiths replied.

R. F. D.

Contents of the Current Issues of the *Proceedings*

DATE OF JOURNAL REVIEW OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (DECEMBER 1956)

See *Journal*, December 1956, page 778.

PART B. RADIO AND ELECTRONIC ENGINEERING (JANUARY 1957)

SIR GORDON RADLEY, K.C.B., C.B.E., PH.D.(ENG.)
January 1957 **Inaugural Address**

Written discussion on **An X-Band Magnetron Q-Measuring Apparatus**

DENIS TAYLOR, M.SC., PH.D.
January 1957 **Measurement and Control Section: Chairman's Address**

R. C. G. WILLIAMS, PH.D., B.SC.(ENG.)
January 1957 **Radio and Telecommunication Section: Chairman's Address**

J. BELL, M.SC.
January 1957 **Ship Stabilization: Automatic Controls, Computed and in Practice** (PAPER No. 2240)

J. BROWN, M.A., PH.D., AND J. O. SPECTOR, PH.D.
January 1957 **The Radiating Properties of End-Fire Aerials** (PAPER No. 2216 R)

A. E. BARRINGTON, PH.D., B.SC.(ENG.), AND J. T. HYMAN, B.SC.(ENG.)
January 1957 **A Non-Resonant Waveguide Window** (PAPER No. 2242 R)

G. L. GRISDALE, PH.D., J. G. MORRIS, B.SC., AND D. S. PALMER, M.A.
Not yet reviewed **Fading of Long-Distance Radio Signals and a Comparison of Space- and Polarization-Diversity Reception in the 6–18 Mc/s Range** (PAPER No. 2239 R)

R. F. BROWN, B.ENG.
January 1957 **Frequency-Modulation Distortion in Linear Networks** (PAPER No. 2196 R)

W. B. ITTNER, III, PH.D., AND H. B. ULSH, M.A.
January 1957 **The Erosion of Electrical Contacts by the Normal Arc** (PAPER No. 2248)

Abstract of the **Chairman's Address to the North-Eastern Radio and Measurement Group**

Discussion on **Electrical and Magnetic Measurements in an Electrical Engineering Factory** before the North-Eastern Radio and Measurement Group, the Mersey and North Wales Centre and the South Midland Centre

Written discussion on **An Investigation into some Fundamental Properties of Strip Transmission Lines with the Aid of an Electrolytic Tank**

PART C. MONOGRAPHS (SEPTEMBER 1956)

See *Journal*, September 1956, page 570.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 21ST DECEMBER 1956

	No. of Contributors	£	s.	d.
£1 000 and over	6	6000	0	0
£100 to < £1 000	30	6586	3	0
£5 to < £100	813	8696	11	3
£2 to < £5	1 942	5305	17	2
Under £2	19 973	10470	0	5
		37058	11	10

PRESENTATION OF THE KELVIN MEDAL

At the invitation of the Awards Committee of the Kelvin Medal, the Council have been pleased to make arrangements for the Medal awarded in 1956 to Sir John Cockcroft, K.C.B., C.B.E., M.A., D.SC., M.SC.TECH., PH.D., MEMBER, to be presented to him at the Joint Meeting with The Institutions of Civil and of Mechanical Engineers, to be held in the Institution Lecture Theatre on the 7th February 1957, at 5.30 p.m.; at this meeting Sir Ifor Evans will deliver the Graham Clark Lecture, about which an announcement appears on p. 8.

The Kelvin Medal, which was first awarded in 1920, is presented triennially as a mark of distinction in engineering work or investigation of the kinds with which Lord Kelvin was especially identified. In practice the award is restricted to men of distinguished service in the application of science to engineering rather than in the development of physical science itself. The Awards Committee consists of the Presidents of the following eight engineering Institutions:

The Institution of Civil Engineers
The Institution of Mechanical Engineers
The Institution of Electrical Engineers
The Institution of Naval Architects
The Iron and Steel Institute
The Institution of Mining and Metallurgy
The Institution of Mining Engineers
The Institution of Engineers and Shipbuilders in Scotland.

The committee receive nominations from leading engineering societies in all parts of the world, and thus have before them a comprehensive list of names of eligible persons from all countries irrespective of nationality.

PROGRAMME OF MEETINGS

The programme card of London Meetings for the second half of the session is being sent with this issue to all members not residing within the area of a Local Centre or Sub-Centre.

Any member living in the provinces who often visits London, and is thus able to attend London Meetings may obtain a copy of the London card on application to the Secretary.

THE FARADAY LECTURE

13TH FEBRUARY 1957

Members are reminded that the Faraday Lecture will be delivered by T. E. Allibone, D.SC., F.R.S., CHARTERED ELECTRICAL ENGINEER, at the Central Hall, Westminster, on Wednesday, 13th February 1957, at 6 p.m., his subject being *Nuclear Energy in the Service of Man*.

The primary object of the Faraday Lecture is to increase the interest of the general public in electrical matters, particularly those having an immediate bearing on the life of the community. **Members are therefore asked to bring the Lecture to the notice of their friends.**

Admission is free by ticket obtainable from the Secretary; members should enclose a stamped addressed envelope with their applications.

CONSTITUTIONS OF COMMITTEES, AND REPRESENTATIVES OF THE COUNCIL

The constitutions of various Committees of The Institution, including Local Centre Committees, Oversea Branches, Committees, and Joint Groups, and the names of the Council's Oversea Representatives and Representatives on other bodies (including the Council for Codes of Practice), will be found on pp. 56–72.

COMMUNICATIONS FROM OVERSEA MEMBERS

Oversea members are specially invited to submit, for publication in the *Proceedings*, written communications on papers read before The Institution or published in the *Proceedings* without being read. The contributor's country of residence will be indicated. Brief articles, items of news and photographs intended for the *Journal* will also be most welcome.

Copies of all papers read before The Institution are sent to each Oversea Representative of the Council for distribution to members likely to be in a position to submit communications.

MEMBERS TRAVELLING TO AND FROM THE UNITED KINGDOM

Members visiting or taking up residence in the areas of any of the Oversea Branches, Oversea Committees or Joint Oversea Groups, which are listed on pp. 63 and 64, are invited to apply to the Secretary of The Institution for a letter of introduction to the appropriate Honorary Secretary.

The Secretary will be obliged if members coming home from oversea will inform him of their addresses in this country, even if they do not desire a change of address to be recorded in the Institution register. This will enable him to advise such members of the various meetings, etc., of The Institution and its Local Centres, and, when occasion arises, to put them in touch with other members.

The Secretary will be pleased if those members from oversea who are able to visit the Institution premises will call upon him.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

Members are reminded that notifications of changes of address should be made to the Secretary of The Institution in

London. Where a transfer from the area of one Local Centre or Sub-Centre to another arises as a result of a change of address, this transfer is automatically arranged by headquarters and the member concerned need not notify also the Honorary Secretary of the Local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested, when notifying a change of address, to give their full initials, their previous address and their class of membership.

SUPPLY SECTION DINNER-DANCE

The annual Dinner-Dance of the Supply Section will be held in the Grand Hall at the Criterion, Piccadilly Circus, London, W.1, on Tuesday 5th March 1957 at 7 for 7.30 p.m.

Application forms are being sent separately this month to all members of the Section.

SPECIAL SUPPLEMENTS TO THE *PROCEEDINGS*

An order form for copies of the special Supplements to the *Proceedings* covering the Symposium of papers on the Transatlantic Telephone Cable, and the Convention on Ferrites is now available. It is being enclosed with this month's *Journal* to all subscribers to Part B of the *Proceedings*, and to the members of the Measurement and Control, and Radio and Telecommunication Sections. Copies of the order form may also be obtained on application to the Secretary. Individual copies of the Transatlantic Telephone Cable papers are now available (see December *Journal*, p. 765).

CITY AND GUILDS OF LONDON INSTITUTE

THE INSIGNIA AWARD IN TECHNOLOGY

The Insignia Award in Technology was established in 1952 by the Council of the City and Guilds of London Institute with the following objects in view:

To encourage, through progressive study and practice, the advancement of the technical knowledge of those already engaged in industry, thus helping to meet the national requirements for technical personnel in positions of responsibility.

To emphasize the value of technical training based primarily upon practical experience supplemented by theoretical study, as distinct from the more academic training for which many educational facilities and inducements already exist.

The award is intended to be a mark of distinction for those who have combined sound practical training with an adequate knowledge of the fundamental scientific principles of their subject, and who show a capacity for leadership, administration, and for the effective application of their wider knowledge in industry.

The Insignia Award recognizes the merits and achievements of those who have not necessarily studied at a secondary school or university; it is particularly applicable to men who are studying part-time while they are employed in industry. It is a recognition of achievement by those who succeed and an encouragement to those who try.

Eligible applicants must be at least 30 years old, have been employed for at least seven years in industry, and have gained either the Institute's full technological certificate or a suitable alternative. An applicant must submit a thesis upon an industrial subject, and be interviewed by a panel. The Insignia Award is indeed made only to people of high calibre, and a technologist can be justly proud of being entitled to the letters C.G.I.A. In the 3½ years since the award was established the Council of The Institute have been greatly encouraged by the support from industry and from professional bodies. The Council are convinced that the award is making an increasing contribution towards meeting the serious need for experienced technologists and industrial managers.

The award is administratively organized in five broad industrial groups: chemical, constructional, electrical, mechanical and textile. Candidates have come from many countries oversea as well as from the United Kingdom, and some special panels to interview candidates have met abroad. Among members of The Institution who have already received the Award in the electrical or the mechanical group are the following:

J. W. Dunford, A.M.I.C.E., ASSOCIATE MEMBER
L. M. Jockel, M.I.MECH.E., MEMBER
E. H. Jolley, MEMBER
R. McGlashen, ASSOCIATE MEMBER
J. A. Mason, M.M., MEMBER
H. A. Odell, ASSOCIATE MEMBER
W. B. Shannon, M.I.C.E., M.I.MECH.E., MEMBER
H. Stanesby, MEMBER
W. H. Stimson, ASSOCIATE MEMBER

Further particulars of the Insignia Award may be obtained from the Director (I.A.), City and Guilds of London Institute, Gresham College, Basinghall Street, London, E.C.2.

THE INSTITUTE OF RADIO ENGINEERS

MEETING TO DISCUSS MICROWAVE FERRITES

The 1957 Annual Meeting of the Professional Group of The Institute of Radio Engineers on Microwave Theory and Technique will be devoted to a discussion on 'Microwave Ferrites and Related Devices and their Applications'. The meeting will take place on the 9th and 10th May 1957, and there will probably be two sessions of contributed papers and a special discussion on the design limitations of microwave ferrite devices, covering such matters as low- and high-frequency limits, anomalous propagation in ferrite-loaded waveguides, 'fast' ferrite devices, and bandwidth problems. Papers intended for reading at this meeting must be submitted by the 1st March 1957. Further information may be obtained from the Secretary, The Institute of Radio Engineers Inc., 1 East 79 Street, New York 21, N.Y., U.S.A.

THE OSBORNE REYNOLDS SOCIETY

A society of former members of the Engineering Department at Manchester University has been set up under the name of the first Beyer Professor. Particulars will be sent on request to the Secretary, Professor J. A. L. Matheson, Engineering Department, The University, Manchester, 13.

COURSE ON TENSOR ANALYSIS

The University of Liverpool is arranging a residential course of one week's duration on 'Tensor Analysis Applied to Electrical Engineering'. This is intended as an introductory course for engineering graduates, and will be held from the 7th to 12th April 1957 in Derby Hall, a University hall of residence in the suburbs of Liverpool. The lecturers will be Mr. J. W. Lynn, Mr. C. V. Jones and Dr. W. J. Gibbs.

In announcing the course, the University provides the following comment on it:

The applications of tensor analysis are well known in physics. This branch of mathematics has for many years played an important part in the development of subjects such as the geometry of *n*-dimensional spaces, dynamics of systems having many degrees of freedom, the theory of relativity, and the study of gravitation and unified field theories.

There is now a growing recognition of the industrial significance of this subject, and the present course of sixteen lectures is designed to give an introduction to the application of tensor analysis to electrical engineering problems. A generalized tensor form of Lagrange's equations is used to develop a unified dynamical theory of electrical networks and machines. The lectures embrace such topics as the systematic reduction of complex networks, symmetrical components, multi-loop servo transfer-functions, the theory of rotating electrical machinery and machine equivalent circuits.

The inclusive fee for the course is £12 12s. Further information may be obtained from the Director of Extra-Mural Studies, The University of Liverpool, 9 Abercromby Square, Liverpool, 7.

ROBERT BLAIR FELLOWSHIP, 1957

The London County Council have announced that one Robert Blair Fellowship in Applied Science and Technology will be offered for award in 1957. The successful candidate will be required to pursue a course of advanced study or research in the Commonwealth, in the United States or in any other country abroad. The value of the award will vary according to the approved costs of the candidate and may be up to £2000 if the country selected is Canada or the United States.

Applications will be considered from candidates who are natural-born British subjects of at least twenty-one years of age and who have been trained in applied science and technology. In making the award preference will be given to engineering science and to those who have completed a course of engineering study in a London institution or have been identified with the London teaching service. Application forms and further details can be obtained from the Education Officer, London County Council, County Hall, London, S.E.1, before the 28th February 1957.

ENGINEERING EDUCATION IN THE SOVIET UNION

JOINT MEETING OF THE THREE INSTITUTIONS

A Joint Meeting of The Institutions of Civil, of Mechanical and of Electrical Engineers will be held at The Institution of Civil Engineers on the 25th February 1957 at 5.30 p.m., when the report of the British delegation which recently visited the U.S.S.R. will be presented for discussion. Tea will be served from 5 p.m. It is hoped that advance copies of the report will be available early in February; they will be obtainable on application to the Secretary.

The British delegation, which arrived in Moscow on the 16th September 1956 and returned to London on the 28th September, consisted of: Professor E. Giffen (*Leader of the delegation*); Mr. W. K. Brasher; Dr. B. N. Cole; Mr. H. E. Dance; Dr. H. L. Haslegrave; Mr. G. S. C. Lucas; Mr. P. E. Sleight; Mr. E. G. Sterland; and Professor A. S. T. Thomson.

The delegation was very hospitably received, and the Minister of Higher Education himself and his senior officers devoted two long interviews to a description of the organization and methods of higher technological education in the Soviet Union. They frankly discussed their problems with the visitors and provided all the numerical data for which the team asked. They also disclosed some of the modifications of their scheme under discussion. A similar frank and friendly atmosphere was encountered at Moscow University, ten technical institutes, two technicums and industrial plants. At these establishments the team studied not only the curricula, examination systems, teaching and laboratory methods, but also the practical training which was carried out.

A month later a team of nine directors and professors from Russian technical institutes returned the visit and spent nearly a fortnight in this country. During this time the members of the British team had many opportunities of continuing the exchanges of views begun in Moscow and Leningrad, and of clearing up a number of points which had arisen after some of the many documents brought back from Russia had been translated.

The British team were able to check many of the statistics which have already been published about the size of the Russian higher education plan, and they made an assessment of the standards achieved in the institutes and technicums.

PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS

The Proceedings of The Institution of Civil Engineers is, from the beginning of this year, being published monthly as a single periodical instead of bi-monthly and quarterly in three parts. The subscription rate for members of our Institution is unchanged from the total price of the three parts that were formerly published, namely £2 per annum. Single copies of any issue are priced at 3s. 6d. each.

SPECIAL COURSES IN HIGHER TECHNOLOGY

The programme of specialized courses at technical colleges in London and the Home Counties for the spring and summer terms, 1957, has been published. Many of them begin in January. A brief description of these courses was given in the *Journal* for September 1956, p. 567. Those interested will find further details in the 'Bulletin of Special Courses in Higher Technology, Part II', issued by the Secretary, Regional Advisory Council, Tavistock House South, Tavistock Square, London, W.C.1, price 1s. 6d., post free.

District Meetings

Arrangements for District Meetings in February other than those in the area of a Local Centre.

February 1957

MAIDSTONE (At Maidstone Technical College, Tonbridge Road, Maidstone, at 6.30 p.m. for 7 p.m.)

4 *Monday* E. L. E. WHEATCROFT, M.A., *and* H. H. C. BARTON, B.A. 'The Potentialities of Railway Electrification at the Standard Frequency' [*Proceedings I.E.E.*, Paper No. 1998 U, January 1956 (103, Part A, p. 411)]

OXFORD (At the Southern Electricity Board, 37 Tonbridge Road, Maidstone, at 6.30 p.m. for 7 p.m.

13 *Wednesday* JOHN WILKES 'Fuel and the Future'*

* No advance information will be available.

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*H. STANESBY

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*F. R. C. ROBERTS

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*PROFESSOR J. M. MEEK, D.ENG.

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*A. H. KENYON

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Deputy Secretary F. JERVIS SMITH, M.I.E.E.
Assistant Secretary F. C. HARRIS

Committees, 1956-57

The President is, *ex officio*, a member of all Committees of The Institution.

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*J. G. Craven (28.6.51)
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*C. E. Mills (3.4.52)
*E. J. Sutton (12.5.49)
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L. H. A. Carr, M.SC.TECH. (2.2.56)
The Secretary of The Institution (or his deputy)
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*H. W. Grimmitt (13.5.48)
Further appointment pending
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TECHNICAL COMMITTEE ON TRAMWAY POLES (ELE/24)
T. S. Pick, B.SC.(ENG.) (3.2.49) . .

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*H. W. Grimmitt (12.1.50)

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SUB-COMMITTEE ON ACCESSORIES FOR LAND BOILERS (MEE/34/7)
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SUB-COMMITTEE ON FANS FOR GENERAL PURPOSES (MEE/39/4)
Professor R. O. Kapp, B.SC. (25.6.53)

SUB-COMMITTEE ON MINE FANS (MEE/39/5)
P. N. Wyke, B.SC. (25.6.53)

SUB-COMMITTEE ON INTERCHANGEABLE CRANE COMPONENTS (MEE/41/11)
G. C. Oram (1.3.56)

TECHNICAL COMMITTEE ON METHODS OF TEST FOR DUST EXTRACTION PLANT (MEE/48)
C. L. Blackburn, B.A. (5.9.34)

TECHNICAL COMMITTEE ON LIFTS, HOISTS AND ESCALATORS (MEE/49)
L. J. Gooch (1.3.45)

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A. T. Dover (1.3.45)
The Secretary of The Institution (or his deputy)

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L. H. A. Carr, M.SC.TECH. (16.1.47)

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E. Jacobi (23.6.48)

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G. O. Watson (16.1.47)
Further appointment pending

TECHNICAL COMMITTEE ON HYDRAULIC TURBINES (MEE/125)
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B. Wood, M.A. (22.9.55)

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C. E. Mills (23.6.49)

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C. E. Mills (26.6.54)

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Appointment pending

TECHNICAL COMMITTEE ON SAFETY COLOUR CODE (PSM/12)
F. H. Mann (14.5.53)

TECHNICAL COMMITTEE ON CONDUCTIVE RUBBER (RUC/2)
H. K. Cameron, B.SC., PH.D. (3.11.49)

TECHNICAL COMMITTEE ON RUBBER BELTING (RUC/16)
Appointment pending

TECHNICAL COMMITTEE ON RUBBER FLOORING (RUC/33)
H. W. Swann, O.B.E. (4.11.54)

TECHNICAL COMMITTEE ON MANUFACTURERS' TRADE AND TECHNICAL LITERATURE (S/14)
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TECHNICAL COMMITTEE ON NOMENCLATURE AND DEFINITIONS FOR SOLID FUEL BURNING APPLIANCES (SFE/1)
J. I. Bernard, B.SC.TECH. (3.3.49)

TECHNICAL COMMITTEE ON THERMAL INSULATING MATERIAL (SFE/14)
J. I. Bernard, B.SC.TECH. (22.6.44)

PANEL ON THERMAL INSULATING MATERIALS FOR CENTRAL HEATING AND HOT WATER SUPPLY INSTALLATIONS FOR HOUSES OF A FLOOR AREA NOT GREATER THAN 1000 SQUARE FEET (SFE/14/1/2)
J. I. Bernard, B.SC.TECH. (22.6.44)

TECHNICAL COMMITTEE ON BRITISH STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF FLUE GASES INCLUDING INDICATING AND/OR RECORDING INSTRUMENTS (SFE/17)
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TECHNICAL COMMITTEE ON AIR HEATER BATTERIES (SFE/23)
F. Shakeshaft, O.B.E. (16.9.48)

TECHNICAL COMMITTEE ON COAL (SFE/45)
J. D. Peattie, B.SC. (15.1.48)

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C. E. Strong, O.B.E., B.A.I. (13.9.51)
Chairman of the Radio and Telecommunication Section (*ex officio*)

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E. C. Cherry, D.SC. (5.2.53)
The Secretary of The Institution (or his deputy) (5.2.53)

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R. C. G. Williams, PH.D., B.SC.(ENG.) (14.5.53)
The Secretary of The Institution (or his deputy)

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P. N. Wyke, B.SC.	National Coal Board.
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Institution nominees:
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CODE DRAFTING COMMITTEE ON ABATEMENT OF RADIO INTERFERENCE CAUSED BY DISCHARGE LIGHTING (ELCP/15)

Chairman: Capt. C. Higgins, O.B.E., B.SC.(ENG.).
Institution nominees:
E. M. Lee, B.SC. H. Stanesby.

CODE DRAFTING COMMITTEE ON THE GENERAL ASPECTS OF RADIO INTERFERENCE ABATEMENT (ELCP/16)

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The Chairman of the Supply Section (*ex officio*).
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Institution nominee: R. A. Marryat, B.SC.(ENG.).

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Chairman: F. H. Mann.

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Institution nominees:
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P. K. Davis. P. J. Ryle, B.SC.(ENG.).
P. B. Frost, B.SC.(ENG.). The Chairman of the Supply Section (*ex officio*).
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Chairman: H. W. Grimmitt.

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Chairman: H. Stanesby.
Institution nominees:
H. W. Grimmitt. T. M. H. Stubbs.
E. M. Lee, B.SC.

DRAFTING SUB-COMMITTEE (ELCP/21/1)
Chairman: C. W. Sowton, B.SC.

CODE DRAFTING COMMITTEE ON MAINTENANCE OF INSULATING OILS (ELCP/22)

Chairman: P. W. L. Gossling.
Institution nominee: A. W. Stannett, B.SC.(ENG.).

CODE DRAFTING COMMITTEE ON CLIMATE PROOFING OF ELECTRICAL EQUIPMENT (ELCP/23)

Chairman: B. Donkin, B.A.

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Institution nominee: R. A. Marryat, B.SC.(ENG.) (nominated by the Utilization Section)

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Chairman: Appointment pending.

CODE DRAFTING COMMITTEE ON LOADING OF TRANSFORMERS (ELCP/26)

Chairman: Appointment pending.
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Appointment pending (nominated by Supply Section).
Appointment pending (nominated by Utilization Section).

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Institution nominee: F. H. Mann (1.3.56).

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